Dislocation of the Temporomandibular Joint

A Guide to Diagnosis and Management

Nigel Shaun Matthews
Editor

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Editor
Nigel Shaun Matthews
School of Dentistry
Department of Oral and Maxillofacial Surgery
University of North Carolina School of Dentistry
Chapel Hill, North Carolina
USA

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Russell Eric Warburton and Nigel Shaun Matthews

1.1 Introduction

Temporomandibular joint (TMJ) dislocation is characterized by displacement of the mandibular condyle from the glenoid fossa that cannot be self-reduced. TMJ dislocation is rare and results in significant pain, malocclusion, and masticatory dysfunction leading to deformity and disability if not adequately addressed.

Anterior dislocations are more commonly encountered and will be the primary focus of this chapter. Anterior dislocation occurs as the condyle is displaced anterior to the crest of the articular eminence of the temporal bone. Posterior, medial, lateral, and superior dislocations are seldom encountered and are typically associated with fracture of the condyle or temporal bone [1]. Most TMJ dislocations occur bilaterally [2].

1.2 Definition

It is important to distinguish between dislocation, subluxation, and normal mandibular translation. Many patients experience translation of the condyle anterior to the crest of the articular eminence with maximum incisal opening. Obwegeser et al. evaluated 51 subjects with no history of TMJ dysfunction and found that

R.E. Warburton, D.M.D., M.D. (✉)
Department of Oral & Maxillofacial Surgery, School of Dentistry, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

Knoxville, TN, USA
e-mail: rewarburton@gmail.com

N.S. Matthews, F.D.S., F.R.C.S., F.R.C.S (OMFS)
Department of Oral & Maxillofacial Surgery, School of Dentistry, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

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80% (n = 41) demonstrated movement of the condyle anterior to the articular eminence with maximum opening [3]. Sheppard et al., in a radiographic survey of 100 asymptomatic subjects, found that 83.5% of condyles were located at or anterior to the crest of the articular eminence with an incisal opening of 35 mm [4]. Translation of the condyle anterior to the crest of the articular eminence is considered normal if the mandibular movement is painless and without dysfunction [5].

Subluxation occurs when anterior translation of the condyle exceeds the normal range of movement, resulting in an incomplete dislocation that self-reduces [6]. This results in a temporary sensation of joint locking and mild discomfort [7]. Dislocation occurs when anterior displacement of the condyle results in a complete separation of the articular surfaces. Unlike a subluxation, TMJ dislocation cannot be self-reduced, and medical intervention is required to relocate the joint [3, 7].

In rare cases, posterior displacement of the articular disc can result in an "open lock [8]." The patient experiences a sudden inability to close the jaw and significant pain with mandibular movement. Posterior displacement of the disc mechanically impedes translation of the condyle into the glenoid fossa, thereby limiting closure [9]. While similar in clinical presentation, this form of "open lock" does not represent a true dislocation.

1.3 Classification and Etiology

TMJ dislocation can be categorized as acute, recurrent, or chronic [1, 10]. Acute dislocation occurs spontaneously or as a result of trauma, seizure, medication-induced dystonia [11] or excessive mouth opening during endoscopy, laryngoscopy, or dental procedures [12]. TMJ dislocation occurs more frequently in patients with diseases such as Ehlers-Danlos syndrome [13], myotonic dystrophy [14], multiple sclerosis, and Parkinson's disease [15].

Recurrent dislocation is characterized by repeated episodes of dislocation that occur with daily activity [16]. This can result in significant impairment in masticatory function and quality of life.

Chronic dislocation is a consequence of an acute dislocation that goes unrecognized or undertreated. Chronic or longstanding dislocation is rare and can require difficult and invasive surgical intervention to correct the resultant malocclusion and restore masticatory function. It was initially defined by Fordyce et al. [17] as any dislocation that persists longer than 1 month without reduction. More recently, Huang et al. [18] proposed that any dislocation left untreated for longer than 72 h be considered chronic. This takes into account the resolving acute inflammatory response after injury and the onset of granulation tissue formation that characterizes a chronic dislocation.

There are several factors that can contribute to a failure to identify TMJ dislocation in the acute stage. Some patients fail to seek medical evaluation in a timely manner. This may be due to financial hardship or lack of available medical resources [19]. Many medical providers may be unfamiliar with the clinical signs and symptoms of TMJ dislocation, leading to misdiagnosis and delayed patient care. Elderly or medically compromised patients may be at particular risk of a dislocation going unrecognized [20, 21]. An acute dislocation may be neglected as attention is paid to more pressing medical concerns or the patient may be unable to communicate their symptoms due to altered mental status or prolonged intubation. Huang et al. reported six cases of chronic dislocation, four of which were in elderly patients diagnosed after a lengthy ICU admission [18].

1.4 Pathophysiology

The TMJ is divided by the articular disc into superior and inferior joint compartments (Fig. 1.1). The lower joint compartment facilitates condylar rotation. The upper joint compartment allows for translation of the condyle against the articular surface of the temporal bone. The anterior limit of condylar translation is determined by the size and laxity of the temporomandibular capsule and ligaments, and the actions of the masticatory musculature [5].

Condylar movement is dictated by the complex coordination of multiple muscle groups [16]. The masseter, temporalis, and medial pterygoid muscles facilitate mandibular closure. The inferior head of the lateral pterygoid muscle pulls the mandible forward, while the superior head stabilizes the condyle as it returns to the glenoid fossa. The posterior portion of the temporalis muscle is involved with retrusion of the condyle. The digastric, mylohyoid, and geniohyoid muscles help facilitate mouth opening [22]. In addition to their primary function, each group contributes to overall joint stability and harmonious motion with each stage of mandibular function.

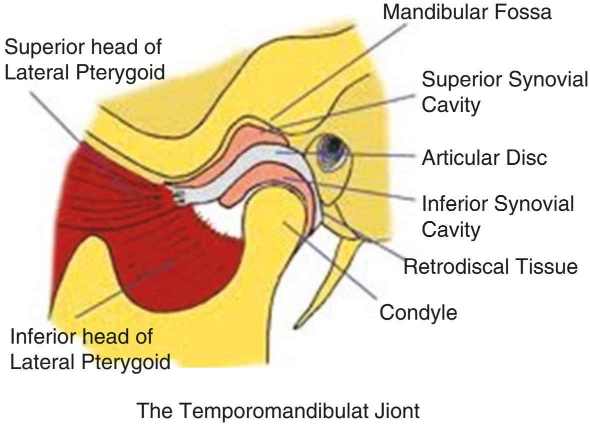

Fig. 1.1 Schematic diagram of the anatomy of the TMJ

Mandibular opening occurs with the coordinated contraction of the lateral pterygoid muscle together with the digastric, mylohyoid, and geniohyoid muscles, and relaxation of the masseter, temporalis and medial pterygoid muscles. This results in the condyle being brought forward, stopping at or anterior to the crest of the articular eminence [5].

Muscle Groups Involved with Mandibular Movement

- Mandibular opening: Digastric, mylohyoid, and geniohyoid muscles
- Mandibular closing: Masseter, temporalis, and medial pterygoid muscles
- Mandibular protrusion: Inferior head of the lateral pterygoid muscle
- Mandibular retrusion: Posterior portion of the temporalis muscle

Mandibular closure begins with relaxation of the lateral pterygoid muscle and activation of the posterior portion of the temporalis muscle. This results in posterior translation of the condyle over the crest of the articular eminence. The masseter, temporalis and medial pterygoid muscles then activate, and the digastric, mylohyoid, and geniohyoid muscles relax, allowing for closure of the mouth. The superior head of the lateral pterygoid muscle remains active to stabilize the condyle during posterior translation [5].

Bell described the initial point of mandibular closure when the condylar head is positioned anterior to the crest of the articular eminence, as the critical period when TMJ dislocation can occur [5]. Disruption of the normal sequence of muscle contracture and relaxation can result in forward luxation of the condyle. Contraction of the masseter, temporalis, and medial pterygoid muscles before relaxation of the lateral pterygoid muscle pushes the condyle anteriorly into the infratemporal fossa [16]. This results in significant muscle spasm, trismus and pain which perpetuate the dislocation and prevent reduction of the joint [12, 16].

Key Points

- TMJ dislocation is most likely to occur during the initial period of mandibular closure when the condyle is positioned anterior to the crest of the articular eminence.
- Disruption in the normal neuromuscular coordination of the masticatory muscles during this critical period can result in forward displacement of the condyle.

The time spent with the condyle positioned anterior to the articular eminence is normally brief. Prolonged mouth opening allows the condyle to remain anteriorly positioned longer than is physiologically normal and creates a greater risk of luxation. Medications or conditions such as seizure, myotonic dystrophy, or multiple sclerosis that adversely affect motor coordination also carry a greater risk of dislocation.

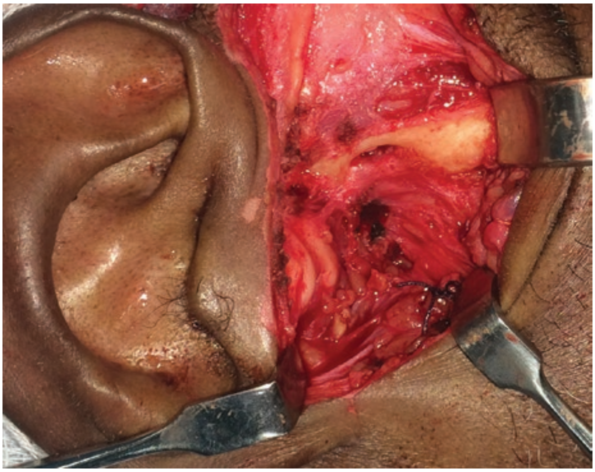

Fig. 1.2 Dense fibrous tissue found within the glenoid fossa after 8 months of chronic TMJ dislocation

Abnormal morphology or degenerative changes to the joint can contribute to dislocation. Laxity of the temporomandibular ligaments or weakness of the joint capsule may predispose a patient to dislocation [12]. Some authors have suggested that condylar atrophy, underdevelopment of the glenoid fossa or aberrant size of the articular eminence may also play a role in the development of acute or recurrent joint luxation [16, 23].

Chronic dislocation is characterized by the development of a progressive periarticular fibrosis, intra-articular adhesions, and dense fibrous ingrowth into the glenoid fossa (Fig. 1.2) [2, 24]. The articular disk can become displaced behind the anteriorly positioned condyle further restricting posterior movement. There can be significant spasm, shortening, and eventual fibrosis of the masticatory muscles with prolonged dislocation [24–26]. Degenerative condylar changes have also been reported [27, 28]. The progressive fibrosis of the TMJ distinguishes chronic dislocation from other forms and is the most significant factor contributing to the difficulty in restoring the condyle to its normal anatomic position in the glenoid fossa.

1.5 Presentation and Diagnosis

Diagnosis of TMJ dislocation is based on clinical exam and confirmed by imaging studies [3]. Radiographic findings alone are insufficient to diagnose a luxation. A detailed history should be obtained to determine the duration of the dislocation and potential inciting cause. Any previous history of dislocation or other TMJ pathology should be established. A comprehensive TMJ examination should be completed on any patient with a suspected dislocation.

Fig. 1.3 Panorex radiograph of a patient with 4-month history of left TMJ dislocation. The left mandibular condyle is anteriorly positioned within the infratemporal fossa with articulation against the skull base

Fig. 1.4 3D reconstruction of a CT scan of the facial skeleton taken of a patient with a 4-month history of left TMJ dislocation

Bilateral dislocation is characterized by an elongated face and prognathic profile [24, 29]. The mandibular condyles are not palpable within the glenoid fossae [10]. The patient frequently exhibits a significant anterior open bite and collapse of the posterior vertical occlusal height. Unilateral dislocation presents with deviation of the mandible away from the dislocated joint and contralateral occlusal crossbite [24]. Mandibular movements are limited, and impaired masticatory function, severe pain, and muscle spasms are often reported [30].

Panoramic radiograph or plain films of the mandible are often sufficient to confirm diagnosis of a TMJ dislocation (Fig. 1.3). CT imaging of the face can be useful to rule out condylar fracture in the setting of a traumatic dislocation or to evaluate for degenerative changes of the condyle with chronic dislocation (Fig. 1.4). There is some value in MRI of the TMJ if posterior displacement of the disc is suspected in the setting of an "open lock" [8].

Chapter Summary

- Temporomandibular joint (TMJ) dislocation is characterized by displacement of the mandibular condyle from the glenoid fossa that cannot be self-reduced.
- Translation of the condyle anterior to the crest of the articular eminence is considered normal if the mandibular movement is painless and without dysfunction.
- Subluxation occurs when anterior translation of the condyle exceeds the normal range of movement resulting in an incomplete dislocation that self-reduces.
- TMJ dislocation can be categorized as acute, recurrent, or chronic:
  - Acute dislocation occurs as a result of a disruption in the neuromuscular coordination of the masticatory muscles. Abnormal morphology or degenerative changes to the joint may be contributing factors.
  - Recurrent dislocation is characterized by repeated episodes of dislocation that occur with daily activity.
  - Chronic dislocation is a consequence of an acute dislocation that goes unrecognized or undertreated. It is characterized by the development of a progressive periarticular fibrosis, intra-articular adhesions, and dense fibrous ingrowth into the glenoid fossa.
- Diagnosis of TMJ dislocation is based on clinical exam and confirmed by imaging studies. Radiographic findings alone are insufficient to diagnose a luxation.

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Imaging of the TMJ

2

Benjamin Huang, André Mol, and Angela Broome

2.1 Introduction

There are a number of techniques available for imaging patients with temporomandibular joint (TMJ) pathologies. These techniques include conventional radiography, panoramic radiography, cephalometric radiography, conventional tomography, arthrography, computed tomography (CT), ultrasound (US), and magnetic resonance imaging (MRI). Prior to the development of cross-sectional imaging techniques such as CT and MRI, noninvasive radiologic assessment of the TMJ was primarily limited to evaluation of the osseous anatomy of the mandible and skull base. Characterization of the soft tissues within the joint space—most notably the articular disc—was only possible through the use of invasive tests such as arthroscopy and arthrography.

In modern clinical practice, the role of imaging internal TMJ derangement has been largely assumed by MRI [1], with arthrography now being performed rarely. For routine hard tissue (i.e., bone) assessment of the mandible, the primary modalities employed currently include panoramic radiography, cone beam computed tomography (CBCT), and multidetector helical computed tomography (MDCT). Each of these technologies presents its own unique advantages and disadvantages, and the optimal imaging paradigm for a given scenario will depend on several factors including test availability, cost, individual patient factors, and the specific question to be answered.

In this chapter, we review the radiologic techniques most commonly employed for mandible and TMJ imaging, their indications, and their relative strengths and weaknesses. Normal imaging anatomy is illustrated along with various pathologic findings associated with TMJ dislocation. Although arthrography and US are occasionally performed at some centers, neither technique is in widespread use, with the

B. Huang, M.D., M.P.H. (✉) • A. Mol, D.D.S., M.S., Ph.D. • A. Broome, D.D.S., M.S.
Department of Neuroradiology, UNC Hospital, Chapel Hill, NC, USA
e-mail: benjamin_huang@med.unc.edu

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former being largely of historic interest and the latter only being employed in a limited range of practices. As such, neither arthrography nor US will be discussed further in this chapter, which will focus on the areas of radiography, CT, and MR imaging of the TMJ.

2.2 Imaging Modalities

2.2.1 Conventional Radiography

Prior to the routine use of cross-sectional imaging, a number of conventional projections were used for the assessment of the TMJs. Whereas the current use of such projections is exceedingly uncommon, their use may occasionally be indicated as they require no advanced imaging equipment and image acquisition is easy and quick. For imaging of the ramus and condylar process, transcranial, lateral oblique, reverse Towne, as well as posterior-anterior (PA) mandible and skull projections are most suitable. They can be acquired with an intraoral or extraoral X-ray source and an extraoral receptor.

Acquisition of transcranial radiographic images involves a receptor placed adjacent to the TMJ region of interest. The tube head is located on the opposite side of the patient with the beam directed perpendicular to the receptor and at an anterior and positive 20-degree beam angle. Images provide a lateral view of the mandibular condyle and glenoid fossa (Fig. 2.1), but are subject to distortion [2, 3]. Oblique

Fig. 2.1 Normal transcranial projection of the right TMJ demonstrating the condyle (*asterisk*), glenoid fossa (*arrowhead*), articular eminence (*straight arrow*), and external auditory canal (*curved arrow*)

Fig. 2.2 PA radiograph of a patient with a left condylar neck fracture and condylar displacement (indicated by the *circled area*). The left condyle is medially displaced and angulated. Note the normal position of the condyle on the right (*asterisk*) (Courtesy Dr. Don Tyndall, Oral and Maxillofacial Radiology, UNC School of Dentistry, Chapel Hill, North Carolina)

mandible projections similarly assess the condyle and glenoid fossa nearest to the image receptor and also visualize the ipsilateral mandibular ramus and body. The receptor is placed adjacent to the side of interest and the X-ray beam is angled 25° cephalad.

For the reverse Towne projection, the patient places the forehead against an extraoral receptor with the canthomeatal line at −30° relative to the receptor. The central ray (CR) of the X-ray beam is pointed perpendicular to the receptor. As the requirement of the patient opening the mouth will be difficult to meet following trauma, a variation of this technique, the PA mandible projection, is usually more suitable. The patient is positioned with the forehead and nose against the receptor, and the orbitomeatal line is perpendicular to the receptor. The CR is pointed perpendicular to the receptor.

PA skull projections are more limited in visualizing the condylar and coronoid processes, but can still be used to assess mediolateral deviations in the anatomy as a result of fracture or dislocation (Fig. 2.2). Major drawbacks of conventional x-ray projections are the lack of 3D information and the superimposition of anatomical structures.

2.2.2 Panoramic Radiography

Acquisition of panoramic radiographic images occurs by rotation and translation of the extraoral receptor and simultaneous rotation of the X-ray source. In digital panoramic radiography using a solid-state detector, translation of the receptor is simulated by the detector read-out timing sequence. Alternatively, multiple non-tomographic images can be acquired from which a tomographic panoramic radiograph can be synthesized through a process called "tomosynthesis." With any of these acquisition methods, structures within a predefined imaging layer are sharp in the resulting image, while structures outside this layer are blurred. Panoramic radiographic images provide an overview of the craniofacial skeleton including the temporomandibular joint regions (Fig. 2.3). In a properly acquired panoramic image, horizontal and vertical magnifications are the same, approximately 125%. Patient positioning errors lead to changes in the horizontal magnification, resulting in image distortion. Although this modality is a form of tomography, substantial superimposition of structures within the image layer limits accurate and reliable assessment of the mandibular condyles and fossae [4, 5]. In addition, when imaging the TMJ areas, the X-ray beam is not aligned with the long axis of the condyles. This results in a distorted view of the condyles, which limits condylar assessment to gross changes in morphology or position.

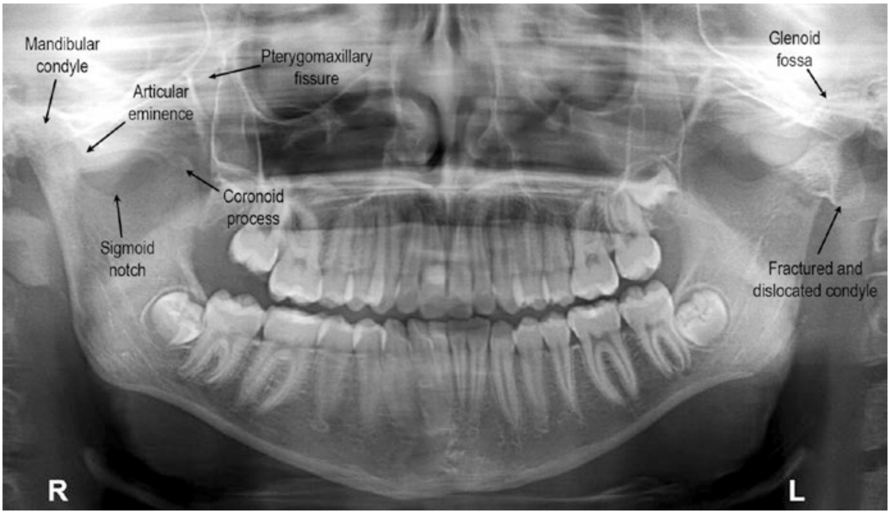

Fig. 2.3 Panoramic radiograph of a patient with a left condylar neck fracture with medial condylar displacement. The patient's right side displays normal anatomy—condyle, articular eminence, sigmoid notch, coronoid process, and pterygomaxillary fissure. The left glenoid fossa is also labeled (Courtesy Dr. Don Tyndall, Oral and Maxillofacial Radiology, UNC School of Dentistry, Chapel Hill, North Carolina)

Relative advantages and disadvantages of conventional and panoramic radiography are outlined in Box 2.1.

Box 2.1 Strengths and weaknesses of conventional and panoramic radiography
Strengths

- Fast
- Inexpensive
- Low dose
- Availability

Weaknesses

- Exposure to ionizing radiation
- Technique sensitive
- Superimposition of structures
- Inability to assess articular disc and related soft tissues

2.2.3 Scanography

Newer panoramic models offer program selections for imaging the temporomandibular joint that produce images comparable to the traditional transcranial projection images for TMJ assessment. However, scanography is a form of tomography, which limits superimposition of adjacent structures. Scanography is comparable to panoramic radiography in the evaluation of the TMJ region [6].

2.2.4 Computed Tomography (CT)

Computed tomography (CT) is an imaging technique which creates cross-sectional images of the internal structure of an object from multiple X-ray projections of the object. The projections are acquired by a rotating X-ray source that is coupled to one or more linear detector arrays (for helical and MDCT) or to a flat panel detector (for CBCT) (Fig. 2.4) [7]. Both MDCT and CBCT are excellent techniques for assessing osseous anatomy and fine bony detail, and are widely used for imaging of the mandible and skull base. CT assessment is typically performed with the patient in maximum intercuspation. Additional CT imaging should not be used to assess the patient in open mouth position, as this increases the radiation burden for the patient. Information regarding range of motion can be obtained by clinical examination or with MRI.

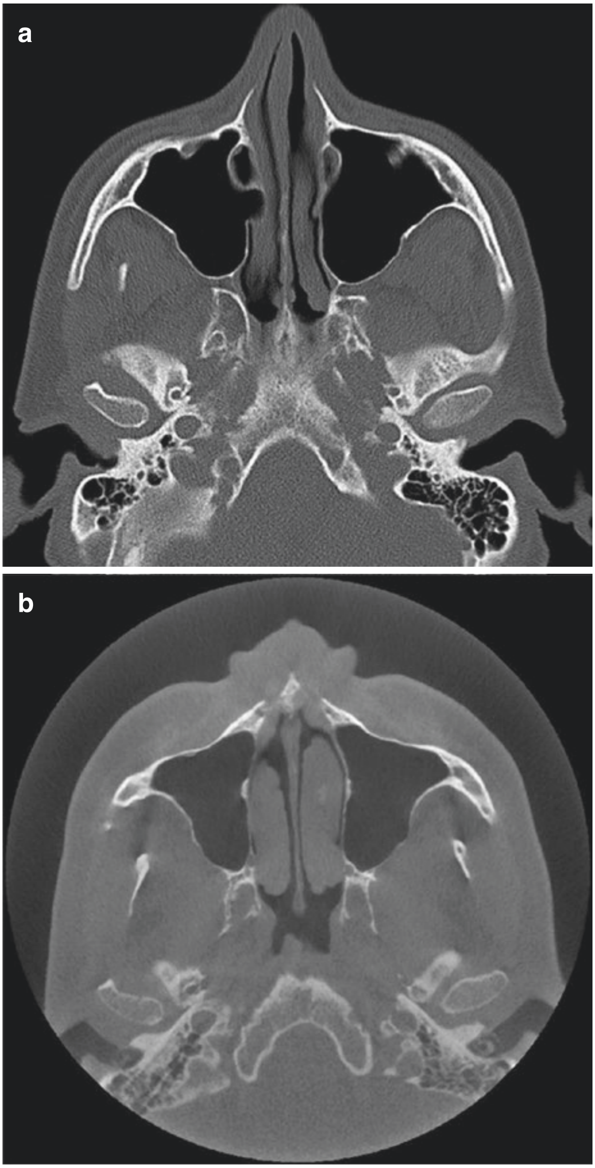

Fig. 2.4 Comparison of MDCT (**a**) and CBCT (**b**) images at comparable levels in the same patient. Both provide excellent resolution and bony detail; however, CBCT images typically have poorer soft tissue contrast compared to MDCT

In both helical CT and CBCT, images are typically displayed as stacks of two-dimensional arrays of gray-scale pixels. Traditionally, each pixel is assigned an intensity value or CT number (measured in Hounsfield units, HU) based on the linear attenuation coefficients of the tissues contained within the pixel volume. An absorbing tissue's linear attenuation coefficient is, in turn, related to the tissue's physical density. For example, a low-density tissue such as fat attenuates a relatively small proportion of the X-ray photons passing through it (allowing more photons to reach the detector) and has a low attenuation coefficient. On the other hand, a dense substance such as cortical bone attenuates a much larger proportion of X-rays, resulting in a higher attenuation coefficient and intensity value. By convention, the displayed brightness of a pixel is proportional to its intensity value or CT number. That is, pixels containing tissues with high attenuation coefficients appear brighter on CT images than pixels containing lower attenuation tissues, making dense tissues such as bone easily distinguishable from less dense tissues such as fat and muscle.

It is important to note, however, that while both CBCT and MDCT generally provide similar information, particularly about osseous structures, there are several important differences between the two techniques that preclude them from being used completely interchangeably. These differences are discussed in greater detail below.

2.2.4.1 Cone Beam Computed Tomography (CBCT)

Cone beam computed tomography (CBCT) is based on the acquisition of multiple radiographic projections with the X-ray source and the detector rotating around the patient in a full circle or in part of a circle. The term cone beam dates back to the first-generation scanners that used a circular image receptor. Current scanners use a rectangular flat panel detector requiring the beam to be collimated into a pyramidal shape. Computer algorithms reconstruct the basic projections into an image volume that can be viewed using 3D software. Software applications are designed for reformatting the image volume to create the most appropriate views for diagnosis, including multiplanar reformatting (Fig. 2.5), panoramic and cephalometric

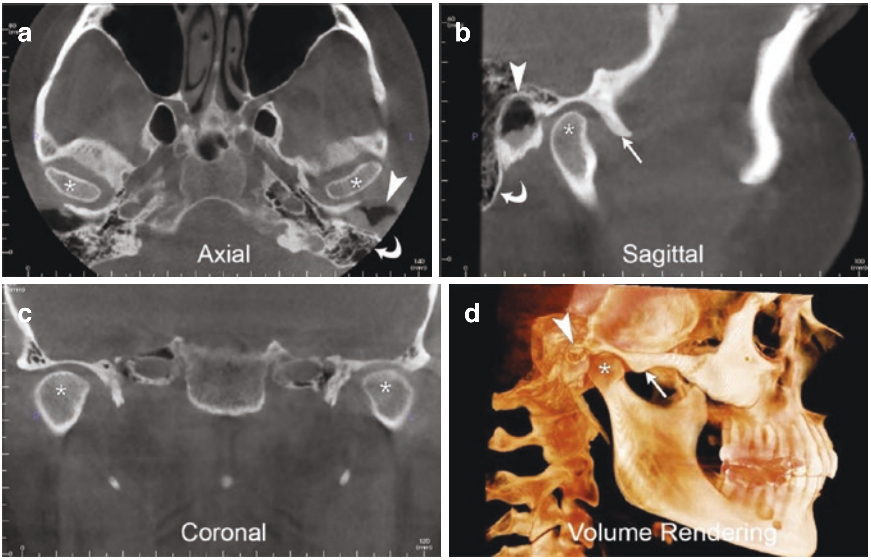

Fig. 2.5 CBCT standard display includes axial, sagittal, and coronal views along with volume rendering. These views demonstrate normal anatomy in all three planes: mandibular condyles (*asterisk*), external auditory canal (*white arrowhead*), articular eminence (*straight arrow*), and mastoid air cells (*curved arrow*)

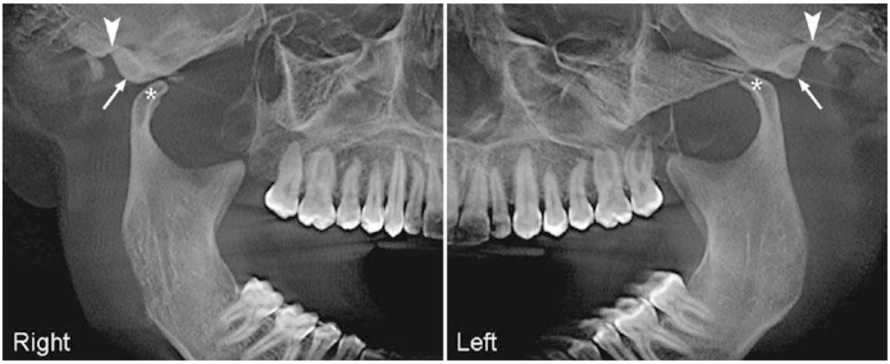

Fig. 2.6 CBCT parasagittal panoramic images of the right and left TMJs showing nontraumatic bilateral dislocations. Both condylar processes (*asterisks*) are dislocated out of their respective glenoid fossae (*arrowheads*). The articular eminences (*arrows*) are within normal limits. Reduction of the condyles may be more challenging with normal or elongated articular eminences

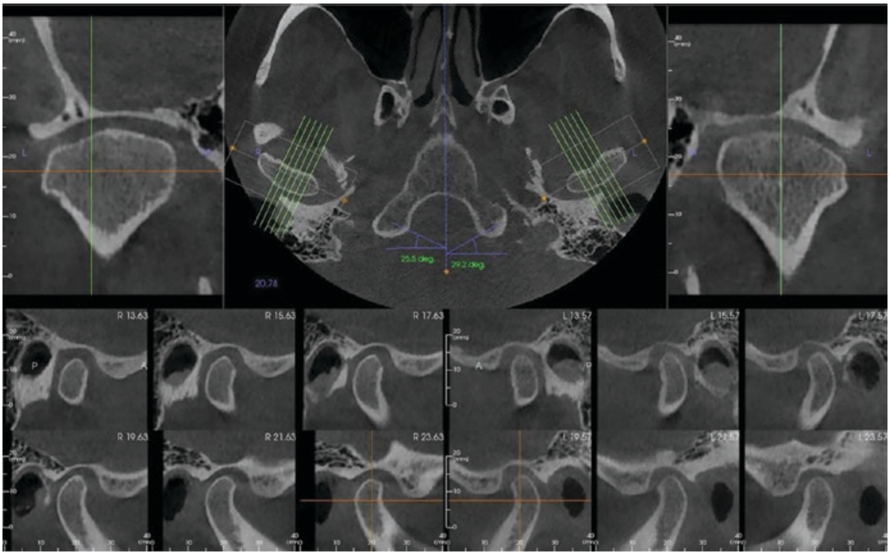

Fig. 2.7 CBCT cross-sectional display of the temporomandibular joints. Reformatting provides serial cross-sectional images of right and left condyles within the same page layout. *Green–red crosslines* provide orientation. *Green lines* correspond to cross-sectional slices

reconstructions (Fig. 2.6), cross-sectional views (Fig. 2.7), as well as volume and surface renderings. As the image volume is made up of isotropic voxels (voxels with identical *x*, *y*, and *z* dimensions), the spatial resolution of the reformatted images is independent of the orientation of these images. Together with the excellent hard tissue contrast, this makes CBCT images particularly useful in evaluating the fine bony structures of the temporomandibular joint.

The relative strengths and weaknesses of CBCT are presented in Box 2.2. Since basic projections are acquired using an X-ray beam that covers the entire field of view, extensive scatter radiation is produced. In fact, more than 80% of the X-ray photons reaching the detector are scatter photons. These photons carry no information about the patient and result in a loss of image contrast. As a result, the diagnostic utility of CBCT is limited to tissues with high inherent contrast, such as bone, and to boundaries between bone, soft tissue and air. Contrast between different types of soft tissue is insufficient for diagnostic purposes. In addition, the displayed gray values for various tissues are not consistent within the image volume or between image volumes. Therefore, CBCT gray values cannot be accurately converted to CT numbers [8, 9].

Box 2.2 Strengths and weaknesses of CBCT

Strengths

- Fast
- Small footprint suitable for dental/medical offices
- Exquisite bone detail
- Potentially higher spatial resolution than helical CT
- Generally lower radiation dose than helical CT
- Multiplanar and 3D reformatting

Weaknesses

- Exposure to ionizing radiation
- Poorer soft tissue contrast compared to helical CT
- Inability to characterize articular disc and related soft tissues
- No Hounsfield units

Regardless, CBCT is well suited for imaging of the hard tissues of the TMJs. It provides a high level of spatial resolution with views fully customized to the anatomy of the patient. CBCT allows assessment of the shape and size of the mandibular condyles, the integrity of the cortical borders, and the presence of osteophytes, subchondral sclerosis, generalized sclerosis, and cortical erosions as indicators of osteoarthritis. It also shows the spatial relationship between the condyles and the fossae. CBCT is also well suited to the diagnosis of traumatic abnormalities of the TMJs, developmental anomalies, arthritic conditions, articular loose bodies, and neoplasia. Typically, the patient is scanned using a medium or large field of view to visualize both joints in one image volume. However, two high-resolution small field-of-view scans can also be used for this purpose. A large number of CBCT scanners are available to the dental and medical practitioner, which vary in field of view, image quality, and dose, among other factors.

2.2.4.2 Multidetector Helical CT (MDCT)

In helical CT imaging, the patient lies on a mobile gantry table, usually in a supine position, and an X-ray tube emitting a collimated fan-shaped beam rotates continuously around the patient, while the gantry moves through the scanner at a constant linear speed. As the X-ray source progresses through each 360° rotation, a ring of detectors surrounding the gantry records the amount of radiation transmitted through the patient. Cross-sectional images are then created from the detected photons using various computational reconstruction algorithms, the most common being a technique known as “filtered back projection.” Virtually all modern helical CT scanners are multidetector (or multichannel) scanners, which utilize multiple parallel rows of detector arrays for data acquisition, so that more tissue is covered per X-ray tube rotation. This allows for much faster scan times, as well as acquisition of higher-resolution datasets compared to early-generation single-channel helical CT scanners. Newer scanners commonly have 64 or more detector channels.

Due to the nature of helical CT imaging and the configuration of gantry tables, patients are usually scanned axially with MDCT; however, the technology allows for the acquired high-resolution data to be reconstructed nearly anatomically in any desired orientation, similar to CBCT. One major advantage of MDCT over CBCT is that it provides images with higher contrast resolution (i.e., the ability to distinguish attenuation differences between tissues in an image) [10], which allows MDCT to provide a much better assessment of soft tissues such as muscle and the articular disc compared to CBCT. That said, the ability of MDCT to characterize the disc is still extremely limited, especially when compared to MRI. The primary disadvantages of MDCT relative to CBCT are higher radiation dose, higher cost, and more significant infrastructure requirements for installation and operation (Box 2.3).

Box 2.3 Strengths and weaknesses of MDCT

Strengths

- Fast
- Widely available in outpatient and hospital settings
- Exquisite bone detail
- Better soft tissue contrast than CBCT—can assess bone and surrounding soft tissues, and soft tissue characterization can be augmented with the addition of intravenous contrast
- Multiplanar and 3D reformatting possible

Weaknesses

- Exposure to ionizing radiation—higher dose than CBCT and conventional radiography
- Requires more space than CBCT to set up
- More expensive than CBCT
- Poor characterization of the articular disc without intravenous contrast

MDCT images of the skull base and mandible are generally reconstructed using an edge-enhancement algorithm which optimizes bone detail, and the images are typically displayed using bone window settings. Window settings reflect the contrast and brightness levels used to display the CT images, with users selecting a window width (*W*) and level (*L*) to emphasize specific tissue types and contrasts. Specific window and level settings vary from practice to practice, but for bone imaging, a typical window setting may be (*W*, *L*) = (~3500, ~700). These window settings provide images similar to those of CBCT, with excellent characterization of fine cortical and trabecular bony detail, but limited assessment of the soft tissues. In MDCT, additional images may be reconstructed using a smoothing algorithm and windowed to better depict soft tissues. These images are typically displayed with a narrower window setting (*W*, *L*) = (400, 70); however, it is important to keep in mind that at these settings, fine bony detail is lost (Fig. 2.8).

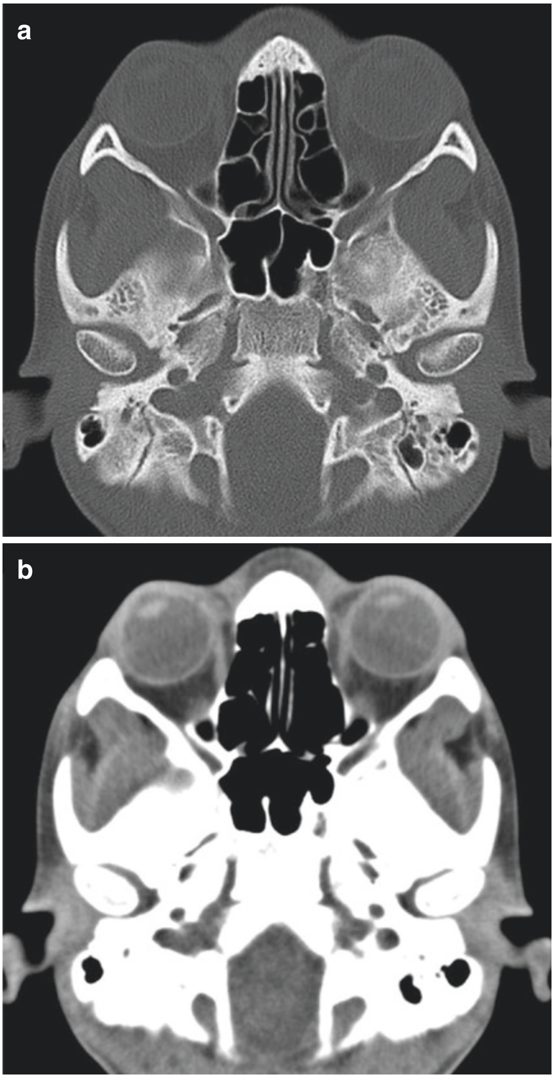

Fig. 2.8 Bone tissue and soft tissue windows on MDCT. The same axial image viewed in a bone window (**a**) and a soft tissue window (**b**). On the bone window setting (**a**), the osseous anatomy, including cortical and trabecular bone architecture, is well defined; however, the soft tissue contrast is markedly reduced. With soft tissue windowing (**b**), the contrast between various soft tissues, such as muscle, fat, and the lenses of the eyes, are well depicted, and the tissues are easily differentiated. Fine bony detail is lost, however, with the osseous structures appearing uniformly white

2.2.4.3 Indications for CT Imaging

Both CBCT and MDCT are ideal imaging techniques for evaluating fractures, degenerative changes, bone erosion, resorption or hyperplasia, tumor invasion, and congenital anomalies [11]. CT is also useful for evaluating the position and integrity of implanted components following arthroplasty. In the modern emergency department setting, CT is frequently the preferred imaging study for evaluating patients with facial trauma and suspected TMJ dislocation, because it nicely depicts condylar position and orientation, as well as associated fractures of the mandible and glenoid fossa. CT is also useful for assessing skeletal factors that may predispose to TMJ dislocation, including the morphology of the condyle and articular eminence and the size of the glenoid fossa. Small, short, or atrophic condyles, atrophic articular eminences, and small, shallow glenoid fossae all predispose to TMJ dislocation, while an elongated articular eminence may impede the ability to reduce the condyle after it has been dislocated [12].

2.2.4.4 Normal CT Anatomy and Image Evaluation

Standard CT images of the maxillofacial area are often presented and viewed in three basic orthogonal planes (axial, coronal, and sagittal) (Fig. 2.5). Representative axial and sagittal MDCT images of the TMJ are shown in Fig. 2.9. At rest, the mandibular condyle normally sits within the glenoid (or mandibular fossa), which is a concave depression along the undersurface of the squamous portion of the temporal bone. The fossa is bounded anteriorly by the articular eminence, medially by the petrous portion of the temporal bone, and posteriorly by the tympanic plate of the temporal bone, which also forms the anterior wall of the external auditory canal.

If the condyle is located outside of its normal position in the glenoid fossa at rest, it is considered dislocated or subluxed. Dislocation is defined as displacement completely out of the glenoid fossa, while subluxation refers to lesser degrees of displacement. The condyle can be dislocated anteriorly, medially, laterally, posteriorly, and superiorly. Anterior dislocation, which is the most common form, occurs when the condyle is abnormally displaced in front of the articular eminence (Fig. 2.10). Posterior dislocations are usually associated with fractures of the tympanic plate of the EAC. Medial and lateral dislocations are usually associated with concomitant mandibular fractures (Fig. 2.11). In cases of lateral dislocation, the condyle may be forced laterally and superiorly into the temporal space. Superior dislocations are associated with fractures of the roof of the glenoid fossa, with displacement of the condyle into the middle cranial fossa [13].

In interpreting CT images, the main areas to focus on depend upon acuity and clinical setting. In the setting of acute dislocation or mandibular trauma, the primary concern is confirming dislocation and identifying associated traumatic injuries. In the chronic setting, secondary findings including anatomic variants, degenerative changes, and tumors become increasingly important to evaluate in order to identify a potential cause of dislocation and to aid in treatment planning. A basic checklist of areas to examine on MDCT and CBCT should include the following:

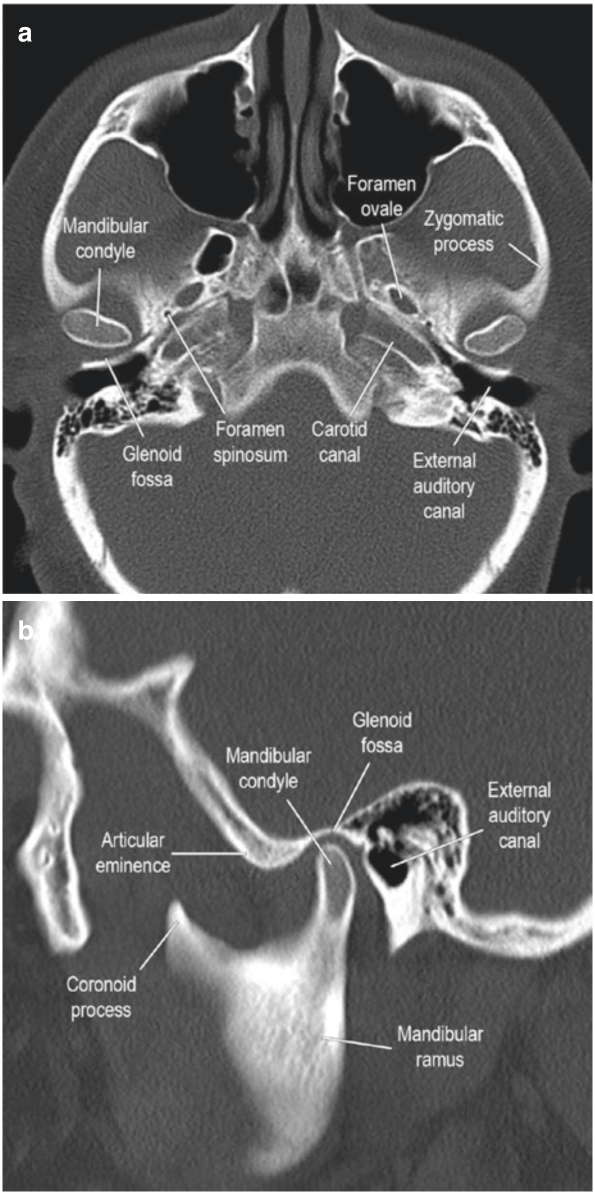

Fig. 2.9 Axial (**a**) and sagittal (**b**) reformatted CT images demonstrating the normal anatomy of the TMJ. The mandibular condyle should be centered in the glenoid fossa between the articular eminence anteriorly and the EAC posteriorly

Acute Dislocation

- Is the condyle centered normally in the glenoid fossa?
- If the position of the condyle is abnormal, is it dislocated or subluxed and in what direction is the condyle displaced?
- Is there evidence of an associated fracture of the mandible or skull base?

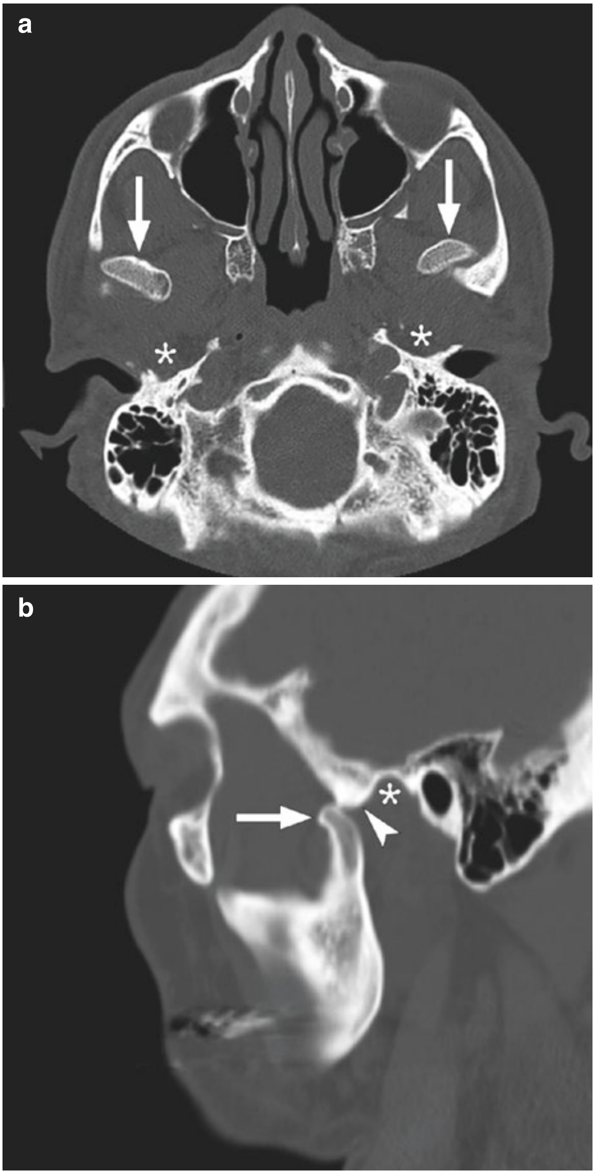

Fig. 2.10 Anterior TMJ dislocations. Axial (**a**), left parasagittal (**b**), and left lateral 3D surface shaded-(**c**) reconstructions from a maxillofacial CT in a 58-year-old male who was unable to close his mouth completely after undergoing dental extractions. On the axial and sagittal images (**a** and **b**), the mandibular condyles (*arrows*) are not in their normal position within the glenoid fossae (*asterisks*). On the sagittal image (**b**), the condyle can be seen anterior to the articular eminence (*arrowhead*), compatible with anterior joint dislocation. The color 3D surface shaded rendering again demonstrates the condyle (*red arrowhead*) anteriorly displaced from the glenoid fossa (*green arrowhead*)

Fig. 2.10 (continued)

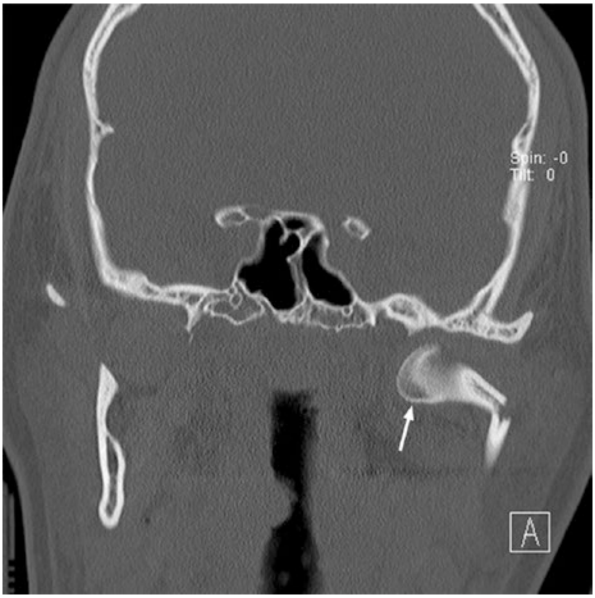

Fig. 2.11 Left condylar neck fracture with medial joint dislocation. Coronal CT image in a patient presenting with trauma demonstrates a medially angulated fracture of the left condylar neck. The left condyle (*arrow*) is medially dislocated

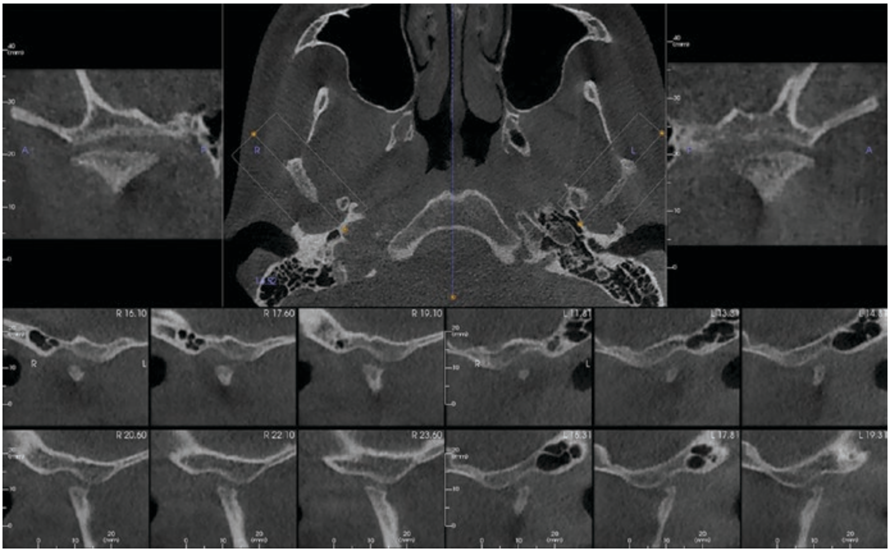

Fig. 2.12 CBCT display view of the temporomandibular joints illustrates predisposing factors for condylar dislocation including condylar erosion, short articular eminence, and a corresponding shallow fossa. Compare to the appearance of these structures in Fig. 2.7

Additional Features of Particular Relevance in Chronic and Recurrent Dislocations

– Are there changes in size of the condyle or condylar neck?
– Are there morphologic alterations of the condyle (erosion, flattening, osteophytosis, pseudocysts, subchondral sclerosis, general sclerosis)? (Figs. 2.12 and 2.13)
– Are there morphologic alterations of the articular eminence (shortened or elongated), glenoid fossa (shallow), or glenoid fossa roof (thickened, thinned, discontinuous, sclerotic)? (Figs. 2.12 and 2.13)
– Is there evidence of extra or abnormal tissue in the joint space (e.g., osteochondral loose bodies, heterotopic bone)?
– Is there evidence of neoplasia?
– Is there evidence of osseous ankylosis? (Fig. 2.14)

2.2.5 Magnetic Resonance Imaging

MRI is a form of medical imaging that takes advantage of the physical properties of hydrogen, which is the most abundant atom in the human body and is found predominantly in water molecules and fat [14]. Specifically, MRI measures how hydrogen nuclei in tissue act when they are placed in a strong magnetic field (usually at 1.5 Tesla or 3 Tesla) and are then repeatedly subjected to excitatory radiofrequency (RF) pulses. Different tissue types can be contrasted to varying degrees by altering

Fig. 2.13 Sagittal CT image of the TMJ in a patient with recurrent right-sided TMJ dislocation demonstrating anterior dislocation of the condyle. The glenoid fossa is shallow and the articular eminence is foreshortened, features which may predispose to recurrent TMJ dislocations. In addition, there are arthritic changes of the condyle, which demonstrates cortical erosions and subchondral cyst formation

Fig. 2.14 TMJ ankylosis in a teenage patient with juvenile idiopathic arthritis. Sagittal reconstructed CT image through the right TMJ shows the right condyle to be fused to the anterior wall of the glenoid fossa (*arrow*) in an anteriorly subluxed position. Heterotopic bone is present anterior and posterior to the condyle (*arrowheads*)

the parameters of the applied RF pulses and by varying the times at which signals produced by the tissues are measured. An individual set of parameters selected to create a group of images is referred to as a "pulse sequence."

For TMJ imaging, commonly employed pulse sequences include T1-weighted (T1W), T2-weighted (T2W), and proton density-weighted (PDW) sequences.

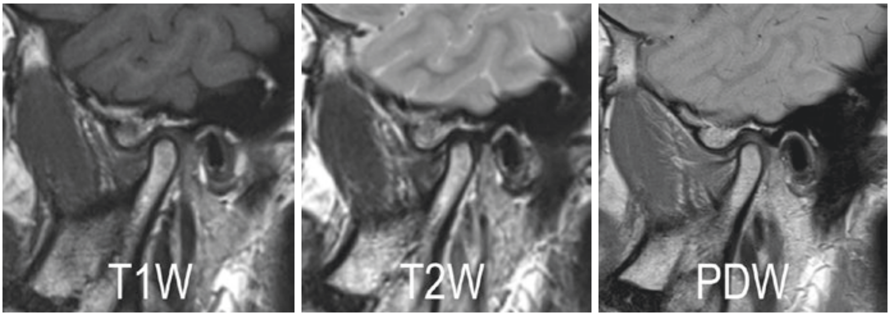

Fig. 2.15 Different MR pulse sequences for TMJ imaging. The sequences can be most easily distinguished by looking at the signal intensity of the cerebrospinal fluid (CSF) within the subarachnoid spaces of the brain just above the TMJ. On T1W images (*left* panel), CSF demonstrates low signal intensity compared to the adjacent brain parenchyma. On T2W images (*center* panel), CSF shows signal intensity higher than the brain parenchyma. On the PDW images, the CSF is slightly higher in signal intensity than the brain

Table 2.1 Relative signal intensities of tissue on MR pulse sequences

Tissue/structure	Pulse sequence			
	PDW imaging	T1W imaging	T2W imaging	STIR imaging
Articular disc	+	+/++	+	+
Muscle	++	++	++	++
Cortical bone	+	+	+	+
Fluid	++/+++	+	+++	+++
Fat	+++	+++	+++	+

+, low signal intensity; ++, intermediate signal intensity; +++, high signal intensity

The relative amount of signal produced by a substance to help create an image on a given pulse sequence is referred to as its "signal intensity," and the signal intensity of a given tissue may vary from pulse sequence to pulse sequence. Structures with higher signal intensities on a sequence will appear whiter on the displayed MR image, while structures with low signal intensities will appear darker. For example, cerebrospinal fluid (CSF) and joint effusions are generally of low signal intensity and therefore appear dark on T1W images, but are of high signal intensity and appear bright on T2W images (Fig. 2.15). The signal intensities of various tissues relevant to TMJ imaging are summarized in Table 2.1.

In general, we find PDW sequences to be the most useful for characterizing the morphology and position of the articular disc. On PDW images, the disc—which is composed of fibrous connective tissue—is of homogeneously low signal intensity compared to the surrounding articular fibrocartilage and the synovium within the joint space (Fig. 2.16) [11].

T2W images are most useful for detection of joint effusions. They are also excellent for demonstrating edema within the condyle when they are acquired using additional fat-suppression techniques. At our institution, we use a short tau inversion

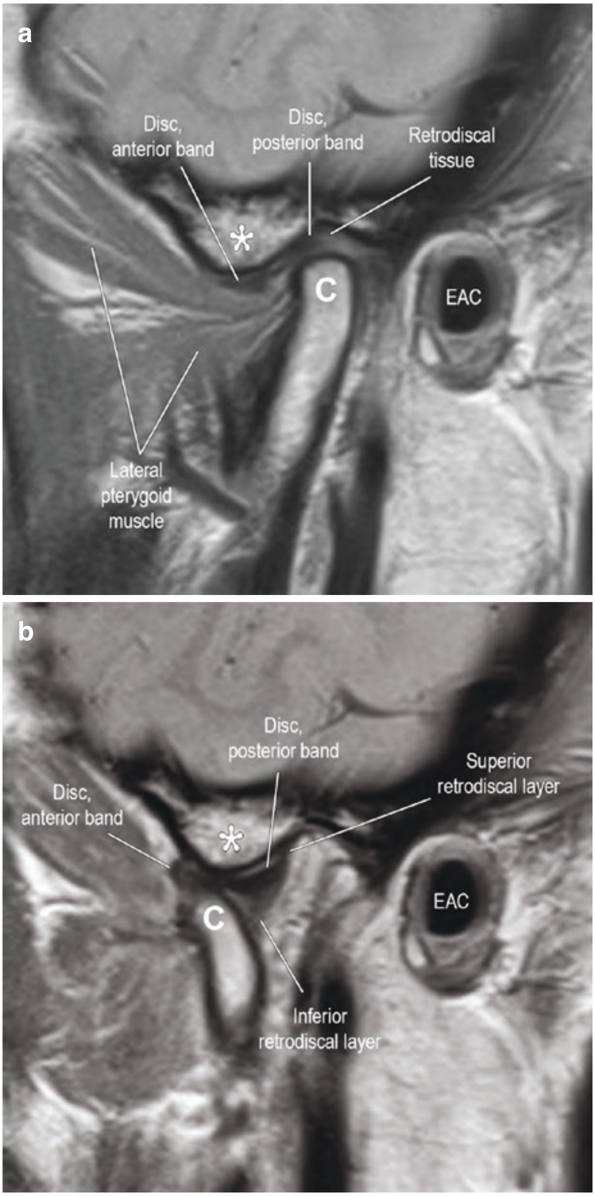

Fig. 2.16 Normal TMJ anatomy on MRI. Closed mouth (**a**) and open mouth (**b**) sagittal PDW MR images demonstrate the normal appearance of the TMJ. On the closed mouth view (**a**), the mandibular condyle (**c**) is normally centered within the glenoid fossa, posterior to the articular eminence (indicated by the *asterisk*). The articular disc appears as an elongated, biconcave, homogeneously low signal intensity structure situated between the condyle and the articular eminence. On the open mouth view (**b**), the condyle rotates and translates anteriorly to rest in a position beneath the articular eminence. The disc slides anteriorly into a position between the condylar head and the articular eminence, assuming a configuration similar to that of a bow tie. The retrodiscal layers can generally best be seen on the open mouth views (EAC = external auditory canal)

Fig. 2.17 Sagittal STIR image of the TMJ in a patient with internal TMJ derangement. STIR images and T2W images are particularly useful for demonstrating joint effusions and condyle edema, which both produce high signal intensity on these pulse sequences. The use of fat nulling techniques (including STIR) further increases the conspicuity of fluid, as the normally high signal intensity of fat is removed. In this case, a large high signal intensity effusion (*arrows*) can be seen distending the joint capsule. The articular disc is not visible and is likely fragmented and displaced (C: condyle)

recovery (STIR) sequence, which provides images similar to fat-suppressed T2W images (i.e., high signal intensity for water and low signal intensity for fat), to look for effusions and bone edema (Fig. 2.17).

T1W images provide excellent overall anatomic detail, with water demonstrating low signal intensity, fat showing high signal intensity, and soft tissues, such as muscle and the articular disc, showing intermediate signal intensities. They are also particularly helpful in demonstrating neoplastic and inflammatory conditions when intravenous gadolinium-containing MR contrast agents are given. Tissues involved by these processes usually take up and retain contrast material and become brighter than they would otherwise appear on non-contrasted T1W imaging, a phenomenon which is referred to as "contrast enhancement" (Fig. 2.18). Areas of contrast enhancement can be further accentuated through the use of fat-suppression techniques, which nullify the normally bright signal of fat.

The relative strengths and weaknesses of MRI are presented in Box 2.4. The primary advantages of MR over CT and radiography are its ability to provide superior soft tissue characterization and its avoidance of ionizing radiation exposure. MRI is well suited for evaluation of soft tissues, such as the articular disc, bilaminar zone, synovium, muscles, and ligaments, as well as for detecting joint effusions and

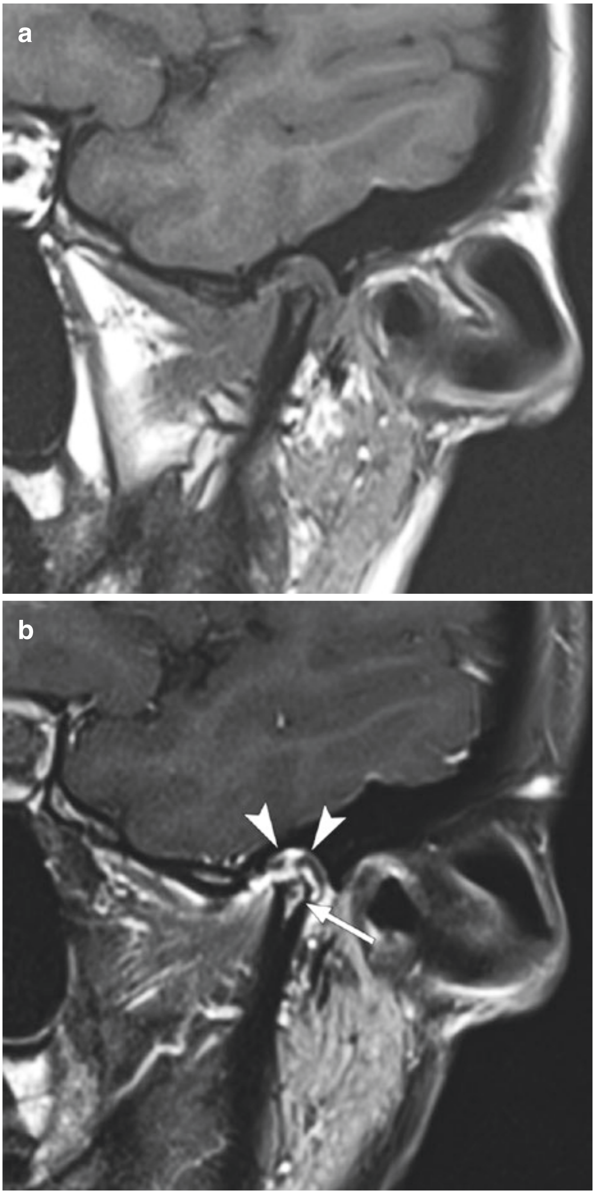

Fig. 2.18 Contrast enhancement on T1W imaging. Sagittal T1W image (**a**) and corresponding contrast-enhanced, fat-suppressed T1W image (**b**) in a 27-year-old female with TMJ pain and crepitus. The unenhanced T1W image (**a**) demonstrates a small and eroded condyle with poor visualization of the articular disc. On the contrast-enhanced image (**b**), there is enhancement of the tissues within the joint space (*arrowheads*) and of the marrow space of the mandibular condyle (*arrow*), suggesting inflammatory synovitis and osteitis. The enhancing tissue in the joint space surrounds curvilinear areas of low signal intensity, which likely represent portions of the fragmented meniscus

condylar edema. That said, MRI is not generally indicated for cases of acute TMJ dislocation in which characterization of bony anatomy of the mandible and skull base is of primary interest. In these types of cases, patients are typically managed without imaging or with techniques such as CT or radiography.

Box 2.4 Strengths and weaknesses of MRI

Strengths

- Excellent soft tissue contrast—allows detailed evaluation of the condyle, joint space, articular disc, and nearby muscles.
- Assessment can be augmented by addition of intravenous contrast.
- No exposure to ionizing radiation.
- Images can be acquired in any orientation.

Weaknesses

- More expensive than radiography and CT
- Less bone detail than CT
- Longer imaging time
- More susceptible to image degradation from motion
- Susceptible to image degradation from metallic foreign bodies or implants in the vicinity of the TMJ
- May require sedation for claustrophobic patients

Disadvantages of MRI include higher cost compared to CT and radiography and longer imaging times. As most MRI protocols incorporate multiple pulse sequence acquisitions, each taking up to several minutes, a complete TMJ MR imaging protocol can take up to 30–45 min, depending on what pulse sequences are desired, whether open and closed mouth images are needed, and whether contrast-enhanced imaging is requested. By comparison, the entire head and face can be scanned with CT in a few seconds. Due to the length of each sequence acquisition, MR images are generally more susceptible to image degradation caused by patient motion. Furthermore, MRI is contraindicated in certain patients with implanted devices or foreign bodies which are non-MRI compatible. Claustrophobic patients may also require sedation in order to complete an entire MR scan [11].

2.2.5.1 Indications for MR Imaging

In the setting of TMJ dislocation, MRI is usually reserved for patients with chronic or recurrent dislocations in whom there is suspicion of internal derangement [15]. MRI may also be warranted in cases of suspected non-osseous joint ankylosis, tumor or inflammatory disease [11]. In the latter two situations, additional imaging with intravenous MR contrast agents is usually warranted.

2.2.5.2 Normal MR Anatomy of the TMJ and Image Evaluation

Representative sagittal PDW MR images of the TMJ obtained in both the open and closed mouth views are presented in Fig. 2.16. Sagittal images are typically angled anteromedially to be oriented orthogonal to the long axis of the condyle (usually ~30° of medial rotation). For disc evaluation, patients are typically imaged in both closed mouth and maximal open mouth positions, which allows characterization of condylar translation and disc mobility. Some centers may also include views obtained with an intermediate degree of mouth opening or may obtain cine-MR images while the patient is instructed to open and close his or her mouth, in order to provide a more dynamic assessment of TMJ function compared to static views.

On closed mouth sagittal images through the TMJ, the mandibular condyle is normally centered within the glenoid fossa, posterior to the articular eminence, and the articular disc appears as an elongated, biconcave, homogeneously low signal intensity structure situated between the condyle and the articular eminence. The thickened portions along the periphery of the disc represent the anterior and posterior bands, which are joined centrally by the thinner intermediate zone. The anterior band is approximately 2 mm in thickness, while the posterior band is approximately 3 mm thick [11]. The posterior band continues backward as the bilaminar or retrodiscal tissue, which consists of a superior layer (stratum superior) that attaches to the posterior portion of the glenoid fossa and an inferior layer (stratum inferior) that attaches to the posterior condylar neck. The retrodiscal layers are typically best visualized on the open mouth sagittal views. Also contained in the retrodiscal area are the synovial membrane, blood vessels and nerves, loose connective tissue, and fat [16]. The anterior band of the meniscus joins the anterior joint capsule, which in turn attaches to the arcuate eminence superiorly and to the head of the condyle inferiorly. In some patients, the superior belly of the lateral pterygoid muscle also attaches to the anterior band of the disc.

In normal individuals without internal TMJ derangement, the articular disc resides in the anterior joint space along the anterosuperior aspect of the condyle. If one were to imagine a clockface superimposed over the condylar head, the junction between the posterior band of the disc and the retrodiscal zone typically resides above the condyle within 10° anterior or posterior to the 12:00 position [17]. It has been suggested, however, that disc positions as far as 30° anterior to 12:00 (i.e., the 11:00 position) can be observed in normal asymptomatic volunteers [18]. In our practice, we consider a posterior band location between the 11:00 and 12:00 positions to be normal (Fig. 2.19).

The sagittal open mouth view is necessary for evaluating disc motility, particularly in the setting of a dislocated meniscus. With mouth opening, the condyle rotates and translates anteriorly to rest in a position beneath the articular eminence. The disc slides anteriorly into a position between the condylar head and the articular eminence, assuming a configuration similar to that of a bow tie, with the thinner intermediate zone situated directly above the condyle (Fig. 2.16b) [19]. The retrodiscal layers can generally best be seen on the open mouth views.

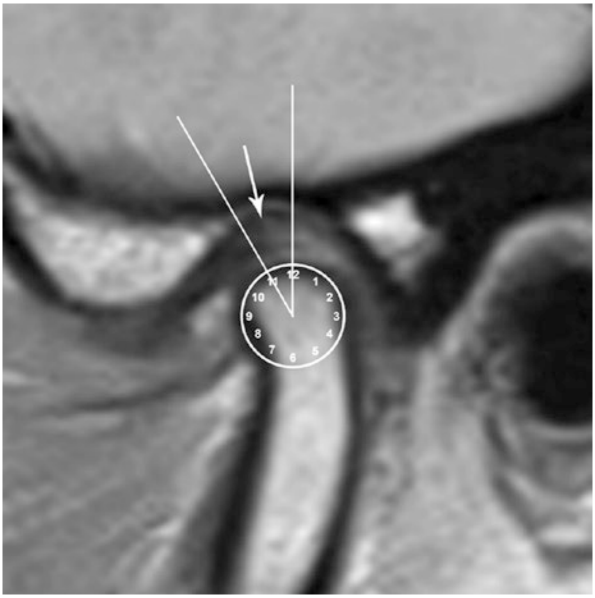

Fig. 2.19 Normal articular disc position. A diagram of a clockface is superimposed on the condylar head on this closed mouth sagittal PDW image of the TMJ. We consider the disc to be normally positioned if the back of the posterior band (*arrow*) is located between the 11:00 and 12:00 positions on the clockface

Lack of visualization of the normal bilaminar appearance on these views may indicate rupture of the retrodiscal layers [20]. In patients with anterior disc dislocation, the articular disc may remain anteriorly displaced with mouth opening (Fig. 2.20) or may reduce into a normal position. The latter occurrence is frequently associated with the sensation of clicking with mouth opening. Posterior displacement of the disc is rare, accounting for less than 0.01% of all disc displacements, but is associated with development of a sudden mandibular open bite (Fig. 2.21) [21].

A basic checklist of areas to examine on MRI should include the following:

Sagittal PDW Images

Closed Mouth

- Is the condyle centered normally in the glenoid fossa?
- Are there morphologic alterations of the condyle (erosion, flattening, osteophytosis)?
- Is the disc visible and normally positioned?
- Are there morphologic alterations of the disc (thinning, thickening, perforation)?
- Is there evidence of extra or abnormal tissue in the joint space (e.g., osteochondral loose bodies, heterotopic bone, PVNS)?

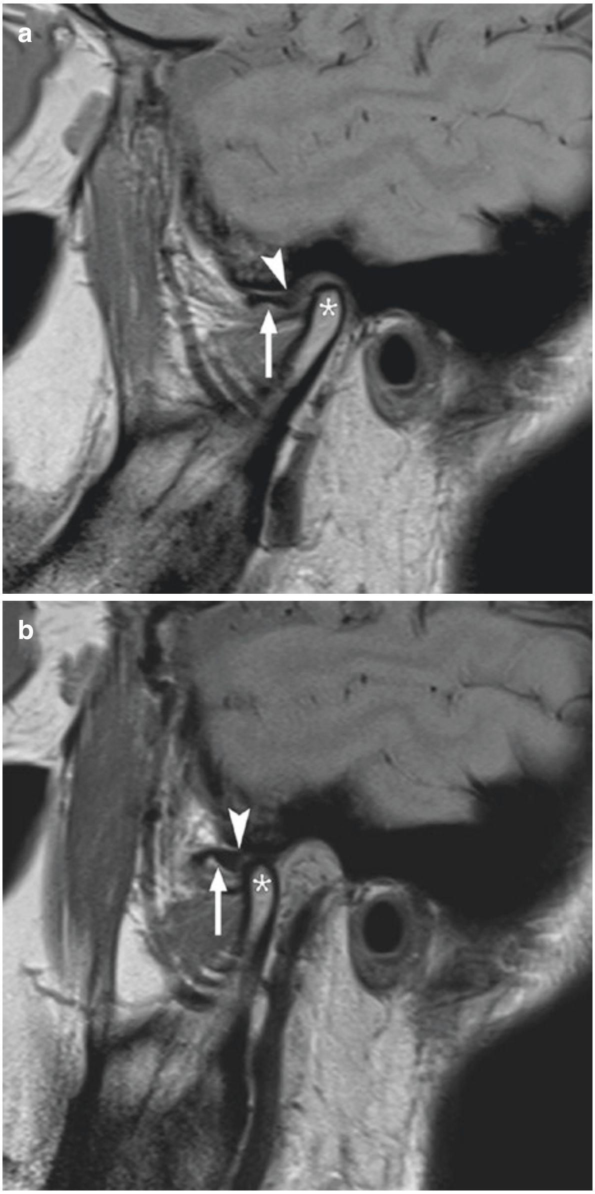

Fig. 2.20 Non-reducible anterior disc dislocation. Sagittal closed mouth (**a**) and open mouth (**b**) PDW images of the TMJ. On the closed mouth image (**a**), the articular disc (*arrow*) can be seen in front of the mandibular condyle (*asterisk*), and the back of the posterior band (*arrowhead*) is situated well anterior to the 11:00 position, indicating an anterior dislocation. With maximal mouth opening (**b**), the condyle (*asterisk*) translates to a normal position beneath the articular eminence, but the articular disc (*arrow*) fails to reduce into a normal position between the condyle and the articular eminence. Note the position of the back of the posterior band (*arrowhead*), which is still anterior to the condyle

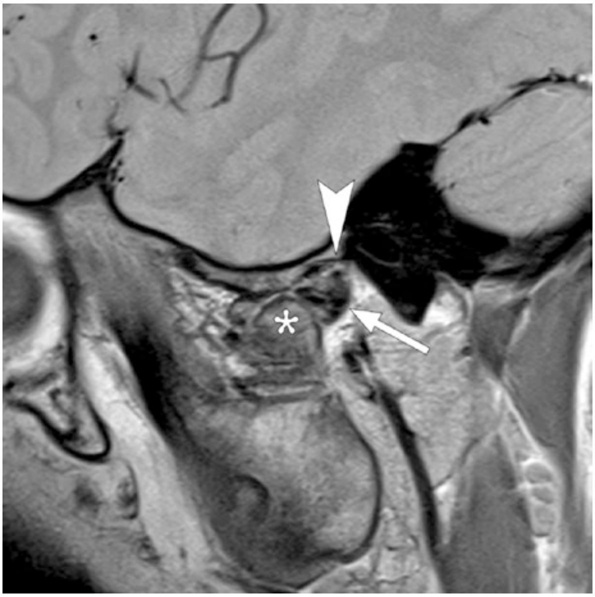

Fig. 2.21 Posterior articular disc dislocation. Sagittal closed mouth PDW MR image of the TMJ in a 12-year-old female with a history of juvenile idiopathic arthritis and progressive TMJ pain. She reported occasional popping with recurrent episodes of open locking. The condyle (*asterisk*) is displaced anteriorly from its normal position in the glenoid fossa (*arrowhead*) and resides beneath the articular eminence. The disc is torn, and there is a large posteriorly dislocated disc fragment (low-signal triangular structure indicated by the *arrow*) remaining in the glenoid fossa. Posterior disc displacement can be associated with development of a sudden mandibular open bite. This case is also notable in that the glenoid fossa appears shallow, the articular eminence is foreshortened, and the condyle appears hypoplastic, features which are all associated with TMJ dislocation

Open Mouth

– Does the condyle translate normally?
– Does the disc move normally (or reduce if dislocated)?
– Are the retrodiscal layers visible and intact?

Coronal Images (T1W or PDW)

– Is there evidence of medial or lateral disc dislocation?

T2W or STIR Imaging

– Is there a joint effusion?
– Is there edema within the condyle or soft tissues?

Contrast-Enhanced T1W Imaging

Is there abnormal enhancement of the joint space, condyle, or surrounding soft tissues?

2.3 Which Study to Order

The choice of which imaging technique to order depends on several factors, including the practice type and setting, test availability, relative costs of the tests, patient-centered factors, and, of course, the specific clinical question to be answered. Generally speaking, if the primary clinical interest revolves around the osseous structures, panoramic radiography and CT are the preferred examinations. If the primary question is one related to the soft tissues, including the articular disc, joint capsule, or surrounding musculature, MRI is the preferred test. At centers which routinely perform US of the TMJ, one may also consider US in some cases, specifically to evaluate the disc and to search for joint effusions. In instances in which both optimal soft tissue and bony assessments are required, ordering of multiple tests, which may include both CT and MRI, may be indicated.

In the urgent care or emergency department setting, imaging may be warranted to confirm the diagnosis of TMJ dislocation and to search for associated fractures. As fractures are rare in cases of nontraumatic TMJ dislocation, conventional projection or panoramic radiography is usually adequate to confirm the clinical diagnosis. However, in situations in which radiography is negative or equivocal but the clinical suspicion for dislocation remains high, a CT should be performed. In cases of suspected traumatic mandibular dislocation, which is often associated with mandible fractures, we recommend CT as the first-line imaging modality, with radiography reserved for cases in which CT is not immediately available. CT has a higher sensitivity for detection of mandibular, midface, and skull base fractures, which may be missed on radiographs as a result of obscuration by superimposed osseous structures or poor patient positioning [11, 22]. Nondisplaced condylar fractures in particular are more likely to be missed on panoramic radiographs than on CT [23].

As previously mentioned, MRI is not a first-line imaging modality in patients with acute mandible dislocations. It is of greatest utility in patients presenting with multiply recurrent dislocations to evaluate potential disc pathology and to identify other non-osseous anatomic features that may predispose to recurrent dislocation. In cases of chronic TMJ dislocation, MRI may also be useful to identify soft tissue abnormalities preventing joint reduction or complications of previous mandibular injury, such as pseudoarthrosis formation. If there is concern for inflammatory or neoplastic disease, MR should be performed with intravenous contrast.

MDCT and CBCT often play a complementary role in patients with chronic and recurrent dislocations. They are particularly useful for providing a detailed assessment of the condyle, glenoid fossa, and articular eminence and may demonstrate bony anatomic features which may predispose to dislocation. They are also well suited for characterizing the presence and extent of degenerative disease (e.g., bone erosion, subchondral sclerosis and geode formation, osteophytosis), bony ankylosis, or heterotopic bone formation. In cases in which MRI is unavailable or contraindicated and better soft tissue characterization is desired, MDCT is preferred over CBCT for the reasons outlined above. In many cases, however, the choice of whether to order MDCT or CBCT may depend on the availability and on the particular practice setting in which a patient is being seen. US, when available, can also be considered to assess disc position and to identify joint effusions in situations in which MRI cannot be performed.

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3 Acute TMJ Dislocation and Technique of Manual Reduction

Kevin Coppelson and Gary Warburton

3.1 Introduction

Temporomandibular joint dislocation accounts for 3% of all joint dislocations [1]. Most oral and maxillofacial surgeons, as well as many dental and emergency professionals, are likely to encounter a patient with acute TMJ dislocation in their career. With a similar presentation to open lock or subluxation, understanding the difference in history, clinical, and radiographic presentations can lead to earlier diagnosis and subsequent treatment. This chapter will focus on providing an understanding of the anatomy and pathology, as well as reviewing the different manual reduction techniques that can be used in the office or operating room settings.

3.2 Definition and Classification

Acute dislocation of the TMJ can be defined as a new-onset displacement of the mandibular condyle outside of its normal functional position within the joint space into a locked position. Distinguishing acute from recurrent or chronic dislocations is important in determining appropriate treatment.

There is no consensus classification system for acute dislocation of the temporomandibular joint. A simple method to describe an acute TMJ dislocation is by the direction of condylar displacement from its normal functional position within the joint space.

As it is usually caused by extremes in normal physiological use, anterior-superior displacement of the condyle past the peak of the articular eminence is the most likely acute TMJ dislocation scenario (Fig. 3.1).

K. Coppelson, D.D.S., M.D. • G. Warburton, D.D.S., M.D. (✉)
Dept. of Oral & Maxillofacial Surgery, University of Maryland School of Dentistry, Baltimore, MD, USA
e-mail: GWarburton@umaryland.edu

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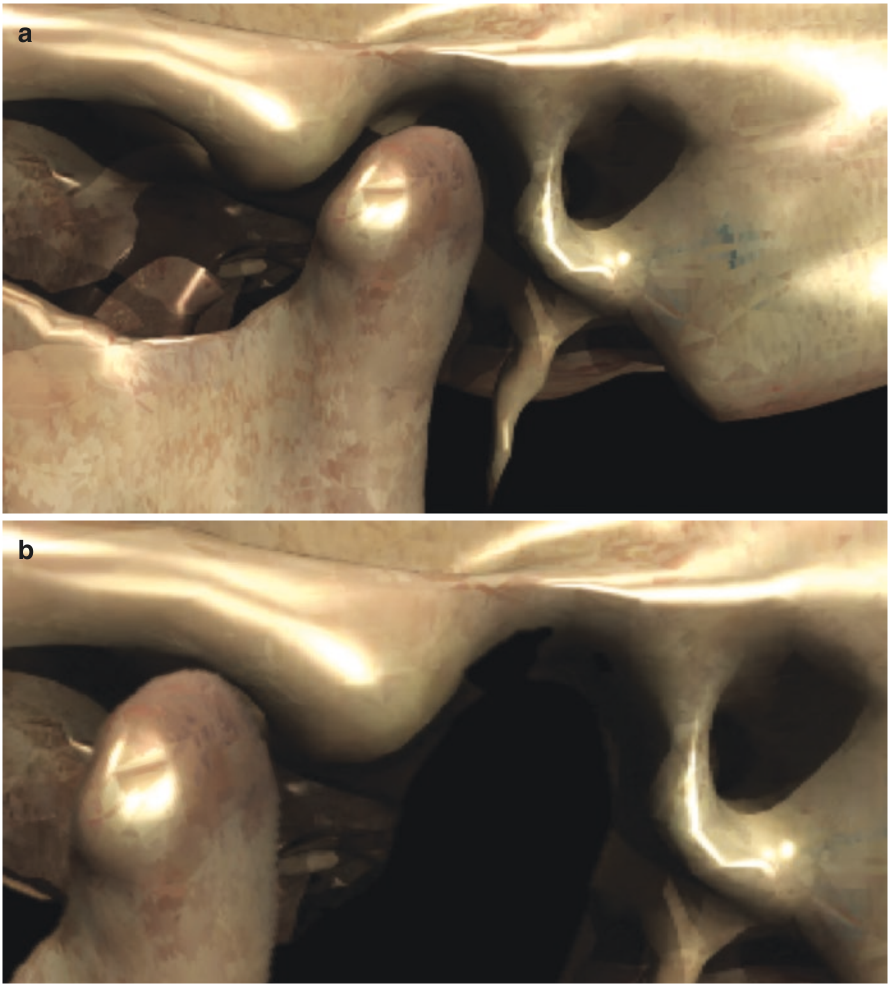

Fig. 3.1 (**a**) Normal anatomical position of the condyle sitting beneath the glenoid fossa and posterior to the articular eminence. (**b**) In anterior-superior dislocation, the condyle is locked anterior-superior to the articular eminence

However, due to the extreme forces one may encounter in trauma, superior (through the roof of the glenoid fossa), superior-lateral, medial, and posterior dislocations of the mandibular condyle have been described in the literature.

3.3 Subluxation vs. Open Lock vs. Dislocation

Subluxation was originally described by Sir Astley Cooper in 1832 as an "imperfect dislocation" [2]. Subluxation describes a condylar position and translation anterior to the peak of the articular eminence that spontaneously reduces.

Table 3.1 Subluxation vs. open lock vs. dislocation

	Position of condyle	Treatment
Dislocation	Anteriorly and superiorly displaced *and locked* in front of the articular eminence	Manual reduction
Subluxation	Anteriorly and superiorly displaced in front of the articular eminence	Spontaneous reduction
Open lock	Obstructed by the anterior band of a lagging articular disc	Minimally invasive TMJ surgery

Open-lock patients present similarly to acutely dislocated patients with the inability to close their mouths. However, rather than the condyle being dislocated and locked anterior-superiorly to the articular eminence, open-lock patients suffer from a mandibular condyle that is obstructed in front of the anterior band of a lagging disc [3].

Correct diagnosis is important so that appropriate treatment can be delivered. An acutely anterior-superiorly dislocated condyle is treated by manual reduction to reposition the condyle into the glenoid fossa, whereas open-lock patients may require surgical intervention in the form of arthroscopic or open joint surgery to address the functional relationship between the articular disc and condyle (Table 3.1).

3.4 Clinical Anatomy

As a ginglymoarthroidal joint, the TMJ is capable of both hinging and sliding movements. At rest and in hinging movements, the mandibular condyle sits near the depth of the glenoid fossa, posterior to the articular eminence. During anterior translation, the condyle slides down the posterior slope of the articular eminence onto the peak of the eminence in conjunction with the articular disc. In subluxation and anterior-superior dislocation, the condyle translates past the peak of the eminence [4].

The temporomandibular joint is formed by the condylar head of the mandible articulating with the glenoid fossa and articular eminence of the temporal bone. The articulation is interposed by a fibrocartilaginous articular disc and is surrounded by a dense fibrous capsule and ligaments. The capsule and ligaments control the position of the condyle and limit its translation, preventing dislocation of the joint in normal function.

Superior dislocations of the condyle are well described in the literature and happen when the condylar head penetrates through a fractured glenoid fossa into the middle cranial fossa. These fractures are a result of trauma and may be accompanied by a concomitant mandibular fracture [5].

In superior-lateral dislocation, the mandibular condyle displaces over the lateral lip of the glenoid fossa into the temporal fossa [6].

Posterior dislocations dislodge the condylar head toward the external auditory canal (EAC) and are often associated with fracture of the tympanic plate and laceration of the EAC. Bleeding within the EAC has been described both before and after reduction [7]. Directions of displacement are summarized in Table 3.2.

Table 3.2 Directions of acute TMJ displacement

Direction of displacement	New condylar location
Anterior-superior	Pre-glenoid plane
Superior	Middle cranial fossa
Superior-lateral	Temporal fossa
Posterior	External auditory canal

Table 3.3 Common causes of acute TMJ dislocation

Causes	Examples
Extremes in physiological use	Singing, yawning, laughter, vomiting
Iatrogenic	Dental treatment, endoscopy, intubation
Disorders of connective tissue	Ehler-Danlos, Marfan syndrome
Disorders of muscular tone or coordination	Parkinson's disease, Huntington's disease, seizure disorder
Medications	First-generation antipsychotics, metoclopramide
Trauma	Particularly trauma sustained during open mouth
Anatomical variations	Deep bite, steep articular eminence

3.5 Common Causes

Anterior-superior dislocation can occur spontaneously and often following extreme physiological use, such as yawning, laughing, singing, and vomiting [4].

Iatrogenic causes include excessive mouth opening during dental care, upper GI endoscopy, transesophageal echocardiography, and endotracheal intubation [8–10].

Connective tissue disorders can increase joint laxity, and dislocation is therefore more likely in patients with Ehler-Danlos and Marfan syndromes [11].

Diseases that affect muscular tone or coordination can result in TMJ dislocation. These conditions include Parkinson's disease, Huntington's disease, muscular dystrophy, and seizure disorders.

Extrapyramidal side effects from neuroleptic medications have been reported as a further cause of TMJ dislocation [12].

The forces of trauma can predispose a patient to derangement of the TMJ architecture, especially when it occurs during mouth opening [13].

Proposed anatomic abnormalities that predispose a patient to TMJ dislocation include deep overbite, deep glenoid fossa, and steep articular eminence [1]. Those with steep eminences may be less likely to spontaneously reduce a condyle that has dislocated anteriorly. Common causes of acute TMJ dislocation are summarized in Table 3.3.

3.6 Clinical Presentation

Presentation of acute TMJ dislocation (Fig. 3.2) includes:

- Inability to close mouth

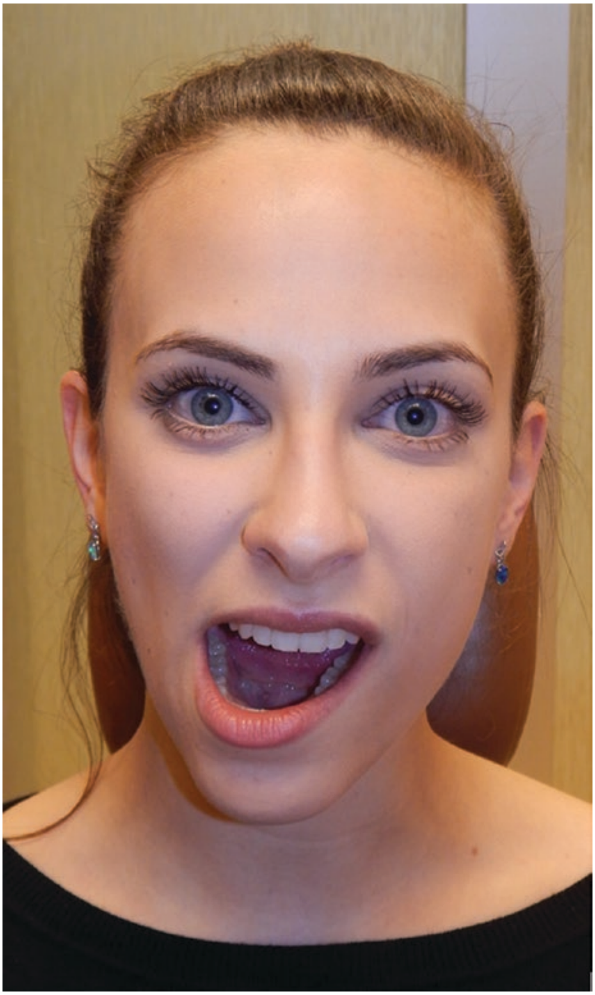

Fig. 3.2 Clinical presentation of anterior-superior dislocation includes the inability to close and deviation of the mandible to the contralateral side

- Deviation of the jaw to the contralateral side
- Preauricular depression (empty fossa) on the ipsilateral side
- Excessive salivation
- Masticatory muscle spasm
- Severe pain of the TMJ [1]

Panoramic radiography or CT/CBCT should be performed to verify an acute TMJ dislocation prior to reduction (Fig. 3.3). In cases of trauma, CT should be

Fig. 3.3 3D reconstruction of CT scan demonstrating anterior-superior dislocation of the TMJ

performed to rule out a concomitant mandibular fracture, which would be a relative contraindication to immediate reduction.

3.7 Reduction Considerations

Classically, acute anterior-superior dislocations of the TMJ can be managed conservatively with manual reduction. The techniques routinely used today are strikingly similar to those described in an ancient Egyptian surgical treatise dating back to around 1600 BCE [14].

Unilateral anterior-superior dislocation of the TMJ is the most common presentation; however, bilateral dislocations are well described in the literature [15]. In cases of bilateral dislocation, it is generally advised to reduce one TMJ at a time.

Immediate reduction is often easier as there is less time for muscle spasm to develop which makes the reduction more difficult.

Many patients can be successfully reduced without the adjunctive use of anesthesia or other pharmacotherapies, especially if reduced immediately.

However, some patients experience a significant amount of pain and distress from the abhorrent joint position along with subsequent masticatory muscle spasm, making the administration of local anesthesia, intravenous sedatives, narcotic pain medication, and even general anesthesia with neuromuscular blockade necessary to facilitate the reduction.

3.8 Role of Local Anesthesia

Post-dislocation masticatory muscle spasm makes reduction more challenging. This difficulty is compounded by the arthrodial and muscular pain that these patients often experience. Local anesthetics can be used as an alternative or an adjunct in cases requiring sedation or general anesthesia, to achieve reduction.

The auriculotemporal nerve provides the predominant sensory innervation to the TMJ. It therefore serves as a reliable tool to relieve arthrodial pain experienced by TMJ dislocation patients. The block is achieved by injecting local anesthetic behind the condylar neck approximately 1 cm below the articulating surface of the condyle.

In 1980, Littler described a single puncture technique below the glenoid fossa where local anesthetic was infiltrated onto the posterior, medial, and lateral aspects of the condylar neck [16]. Young et al. in 2009 described a technique of blocking the masseteric and deep temporal nerves, as well as infiltrating the joint capsule [17].

3.9 Reduction Techniques

Stimulating a patient's gag reflex has been proposed as a method of reducing a dislocated TMJ without the use of force by an operator. The operator uses an instrument, such as a tongue depressor or mouth mirror, to trigger a gag reflex from the patient's posterior soft palate or pharyngeal walls. It is likely that the gag will both relax the spastic elevator muscles, while simultaneously triggering the depressor muscles, thereby allowing spontaneous reduction in some cases [18].

Bimanual reduction techniques should be performed by a standing operator in front of an upright seated patient.

3.9.1 Hippocratic Method

The traditional Hippocratic method for bimanual reduction is the most widely described technique (Fig. 3.4).

This technique involves placing gauze-wrapped thumbs over the molar or retromolar/ascending ramus area of the patient's mandible with the remaining fingers wrapped around the body of the mandible.

First, a downward directed force is applied to distract the condyle down the anterior slope of the eminence. This is followed by a posteriorly directed force to reposition the condyle past the peak of the eminence back into its normal resting position in the glenoid fossa.

Due to the severe masticatory muscle spasms these patients frequently experience, one should not expect an immediate reduction of the TMJ. Constant, gently

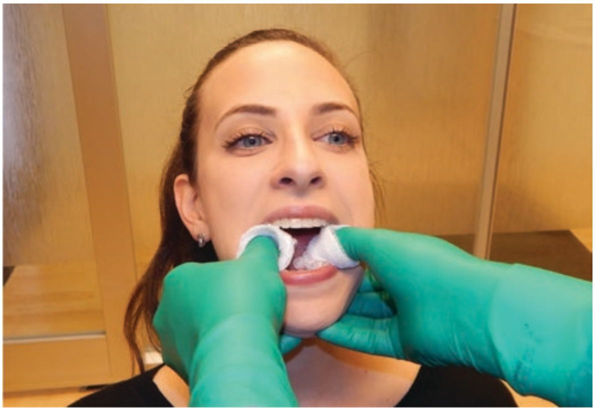

Fig. 3.4 Hippocratic method—thumbs placing downward, followed by posterior force with the remaining fingers wrapped around the body of the mandible

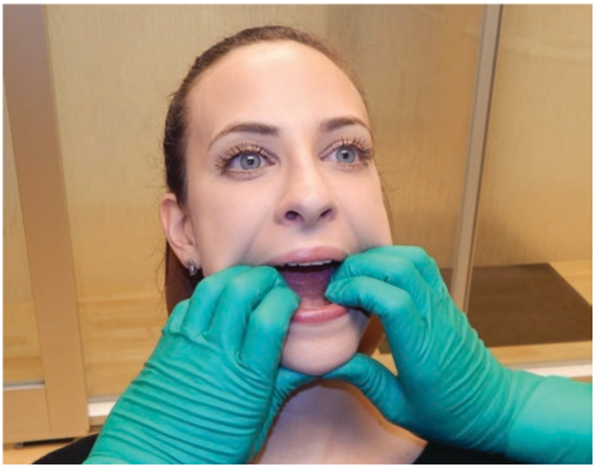

Fig. 3.5 Wrist pivot method—thumbs creating fulcrum on menton (chin point) with remaining fingers providing downward force on posterior teeth

increasing pressure should be applied until the forces of the spastic muscles are overcome.

3.9.2 Wrist Pivot Reduction

This technique involves utilizing a class III lever system to redirect the muscles of mastication to aid in reducing the condyle [19] (Fig. 3.5).

An anterior fulcrum is created by applying upward force on the menton (chin point) with both thumbs.

Effort is exerted by placing fingers on the occlusal surfaces of the bilateral mandibular molars and applying downward pressure.

Fig. 3.6 Interdental block—use of 10 cc syringe as interdental block. Patient is instructed to roll a syringe between the posterior teeth

The contrasting upward force on the anterior fulcrum and downward pressure on the mandibular molars causes an outward rotation, or "pivot" of the wrists, while translating the condyle down the anterior slope of the eminence and past the peak of the eminence into the glenoid fossa.

3.9.3 Interdental Block

The use of interdental blocks has been successfully implemented to treat acute TMJ dislocations (Fig. 3.6).

These techniques utilize a class I lever system by creating a fulcrum between an interdental object and the molars.

One can then bimanually distract the mandible around the newly formed interdental fulcrum.

Alternatively, the patient may be instructed to bite down on and then roll a 5–10 cc syringe between their teeth until reduction is achieved [20].

3.9.4 Extraoral Reduction

With each aforementioned intraoral bimanual reduction technique, the use of a bite block can mitigate the risk of bite injury following reduction. Extraoral reduction techniques were developed to completely remove this risk [21, 22].

Anterior-superior dislocation of the condyle will cause extraoral visual and palpable prominence of the anterior ramus and coronoid process. On the dislocated side, the operator will place their thumb on the anteriorly positioned coronoid process with their remaining fingers bracing around the mastoid process (Fig. 3.7a).

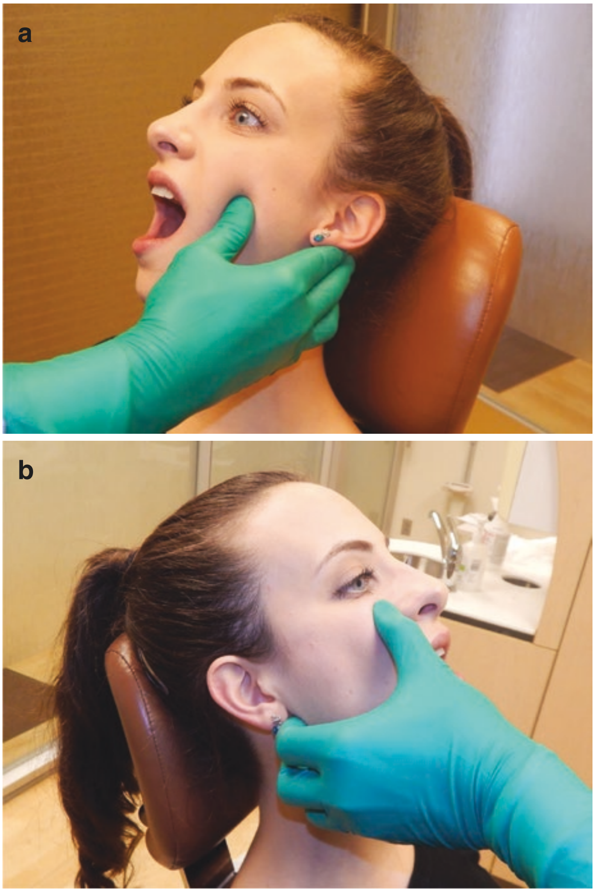

Fig. 3.7 (**a**) Extraoral reduction—on the ipsilateral side, the operator's thumb is applying posterior pressure on the visually exaggerated coronoid process, with the remaining fingers bracing the mastoid process. (**b**) Extraoral reduction—on the contralateral side, the operator fulcrums his thumb off the patient's malar bone and applies anterior force with the remaining fingers braced around the angle of the mandible

On the contralateral side, the operator's thumb will fulcrum on the malar prominence, while the remaining fingers grip the angle of the mandible (Fig. 3.7b).

To initiate reduction, the operator will provide constant pressure using his thumb on the dislocated side and simultaneously pull forward the mandibular angle on the contralateral side.

3.10 Post-Reduction Management

Goals of post-reduction management center around avoiding re-dislocation of the condyle and allowing sufficient time for the now lax or ruptured ligaments and capsule, to heal and strengthen.

This is accomplished by a period of restriction or immobilization of the joint (Fig. 3.8). Most authors recommend a 7-day period of restriction/immobilization

Fig. 3.8 Post-reduction management—the patient's head is wrapped with an elastic bandage, and they are instructed to use a closed fist to restrict excessive mouth opening

Table 3.4 Basic armamentarium checklist

• Personal protective equipment (gown, gloves, mask, eye protection)
• Mouth mirror or tongue depressor—for gag reflex stimulation
• Local anesthetic—for auriculotemporal nerve block or alternative technique
• Gauze—to wrap thumbs in Hippocratic bimanual reduction technique
• Bite block—to protect fingers during intraoral bimanual reduction
• 5—10 cc syringe—use as interdental block
• Facioplasty elastic bandage—post-reduction TMJ restriction

which can be achieved using a facioplasty elastic bandage or even using maxillo-mandibular fixation with Erich arch bars or IMF screws.

During this 7-day period, the patient should be advised to support their chin with a closed fist when yawning.

A prescription for post-reduction pain medications and antispasmodics should be considered. Table 3.4 lists the equipment that may be needed when reducing a TMJ dislocation.

3.11 Summary

- Acute dislocation of the TMJ can be defined as a new-onset displacement of the mandibular condyle outside of its normal functional position within the joint space, into a locked position.
- Anterior-superior dislocation is the most common dislocation of the TMJ. It occurs when the condyle slides past the peak of the articular eminence.
- Subluxating patients can spontaneously reduce an anterior-superiorly displaced condyle.
- Open-lock patients present similarly to acutely dislocated patients with the inability to close, but are *not* treated with bimanual reduction.
- Common causes of TMJ dislocation can be divided into extremes in physiological use, iatrogenic cases of excessive or prolonged mouth opening, connective tissue disorders, diseases that affect muscular tone or coordination, medications with extrapyramidal side effects, trauma, and anatomic abnormalities of the TMJ architecture.
- Symptoms of TMJ dislocation include inability to close the mouth, jaw deviation, preauricular depression, excessive salivation, spastic masticatory muscles, and TMJ pain.
- Radiography should be performed to verify dislocation. In cases of trauma, a CT should be taken to rule out concomitant mandibular fracture.
- Bimanual reduction can be accomplished alone but will often require the adjunctive use of local anesthesia, IV sedation, or general anesthesia.
- Bimanual reduction techniques include the Hippocratic method, wrist pivot method, use of interdental block, and extraoral reduction techniques.
- Post-reduction management will require a 7-day period of restriction/immobilization of the TMJ.

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Chronic Temporomandibular Joint Dislocation

4

Joshua Levy and Gary Bouloux

4.1 Introduction

The temporomandibular joint is unique in that as a ginglymoarthrodial joint with both rotation and translation, it may be more susceptible to dislocation than other joints. The recognition of acute dislocation of the temporomandibular joint is relatively straightforward often characterized by significant pain, inability to close the jaw, and a perceived malocclusion. Management is relatively simple requiring manual reduction under local anesthesia or intravenous sedation. Chronic dislocation of the temporomandibular joint presents many additional challenges, making both the diagnosis and management more problematic.

4.2 Definition

Dislocation of the temporomandibular joint is defined as a condition in which there is a loss of articulation between the glenoid fossa and the mandibular condyle-disc complex as a result of the condyle-disc complex passing anterior and superior with respect to the articular eminence [1, 2]. The frequency and duration of the dislocation can be used to classify dislocation as acute, chronic recurrent, and chronic protracted [1, 3]. Acute dislocation is considered to represent the initial presentation following new-onset dislocation. Chronic recurrent dislocation refers to the development of frequent intermittent but recurrent bouts of acute dislocation. Chronic protracted dislocation refers to an acute dislocation without treatment that progresses over time.

J. Levy, D.M.D., M.D. (✉) • G. Bouloux, M.D., D.D.S., M.D.Sc. (✉)
Division of Oral and Maxillofacial Surgery, Department of Surgery, Emory University School of Medicine, Atlanta, GA 30322, USA
e-mail: gfboulo@emory.edu

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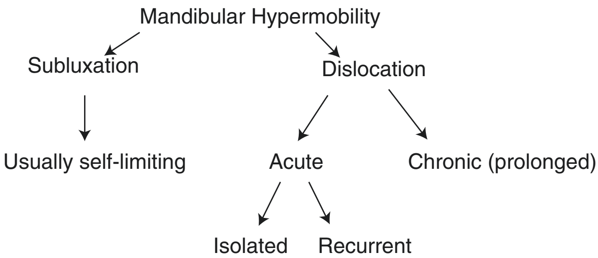

Fig. 4.1 Types of dislocation (Adapted from Liddell A, Perez DE. Temporomandibular joint dislocation. Oral Maxillofacial Surgery Clinic North America. 2015 Feb; 27(1):125–36)

There is no consensus on the duration of time that the dislocation must be present before being considered chronic protracted dislocation. Some authors suggest that as few as 3 days [4], although a more protracted time period, approaching 1 month is considered by most to be the minimum time to be classified as chronic protracted [5]. Despite a lack of consensus, the duration of the dislocation remains critical in that maladaptive changes to the temporomandibular joints and the masticatory muscles occur over time resulting in a situation where traditional manipulation of the mandible under local anesthesia or intravenous sedation is unable to reduce the dislocation (Fig. 4.1).

4.3 Pathophysiology

Dislocation is thought to be caused by a lack of coordination of the muscles of mastication during closure. It is typically seen with the contraction of the protractor muscles including the lateral pterygoid muscle and the jaw elevators including the masseter, temporalis, and medial pterygoid muscles [1]. This leads to the condyle and disc being trapped anterior to the articular eminence. If not acutely reduced, the muscles of mastication go into spasm. This compounds the dislocation by increasing the superior displacement of the condyle/disc making manual reduction more difficult. This also leads to increasing capsular pain which then further increases muscle spasm [3]. A pseudo-joint is formed with the condyle/disc in a new anterior and superior position. Joint rotation can still occur although the ability to translate is lost. The chronic dislocation leads to fibrosis and shortening of the muscles of mastication and ligaments. Fibrous adhesions may also develop between the retrodiscal tissues, disc and glenoid fossa which makes reduction more difficult.

4.3.1 Etiology

The potential etiology of acute dislocation includes the following:

Intrinsic trauma

- Vomiting
- Yawning
- Opening wide
- Seizures

Extrinsic trauma

- Trauma sustained while the mouth is open
- Dental/ENT procedures
- Direct laryngoscopy
- Endoscopy

Anatomic

- Steep eminence
- Abnormal condylar shape
- Internal derangement
- Occlusal discrepancy

Connective tissue disorders

- Ehlers-Danlos syndrome
- Marfan syndrome

Neurogenic disease

- Epilepsy
- Parkinson’s disease
- Huntington’s disease
- Muscular dystrophy
- Dystonia

Pharmacology

- Phenothiazines
- Metoclopramide

4.3.2 Cardinal Signs and Symptoms

- Difficulty eating
- Inability to bring the teeth together
- Jaw deviation on opening and closing
- Preauricular pain

4.3.3 Diagnosis

Clinical exam (Fig. 4.2)

- Anterior open bite, if bilateral dislocation
- Contralateral cross bite, if unilateral dislocation

Fig. 4.2 Photograph of bilateral chronic protracted TMJ dislocation (Adapted from Rattan V, Rai S, Sethi A. Midline mandibulotomy for reduction of long-standing temporomandibular joint dislocation. Craniomaxillofac Trauma Reconstr. 2013 Jun; 6(2):127–32)

- Contralateral mandibular deviation if unilateral
- Preauricular hollowing
- Palpable condyles anterior to the articular eminence
- Facial asymmetry
- Prognathism
- Preauricular pain

Imaging

- Panorex or computed tomography shows condyles anteriorly displaced out of the fossa and anterior to the articular eminence (Figs. 4.3 and 4.4)
- 3D reconstruction can also be used to illustrate the dislocation (Fig. 4.5)

Fig. 4.3 Panorex showing bilateral TMJ dislocation of 5-months duration (*white arrow* points to articular eminence, *red arrow* points to condyle)

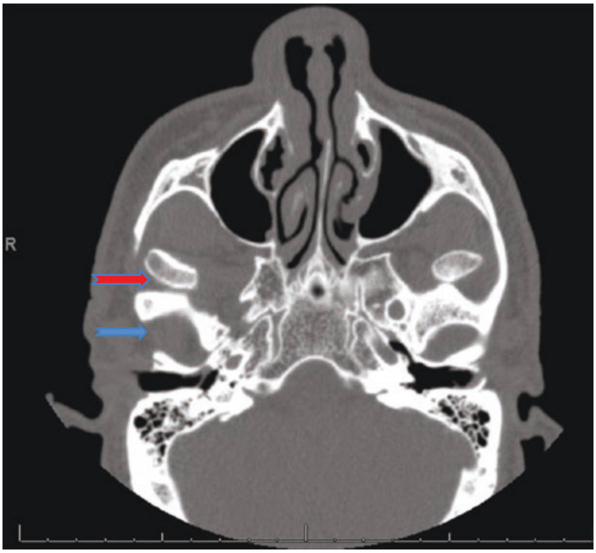

Fig. 4.4 CT scan showing bilateral TMJ dislocation of 5-months duration (*blue arrow* points to the glenoid fossa, *red arrow* points to the condyle)

4.4 Management

There are several choices with regard to treating dislocation.

Manual reduction

- Often very difficult to reduce manually due to joint and muscle fibrosis.
- Place thumbs on mandibular molars and index fingers beneath the mandible extraorally, then pressing down and backward to move the condyles back into the fossa.

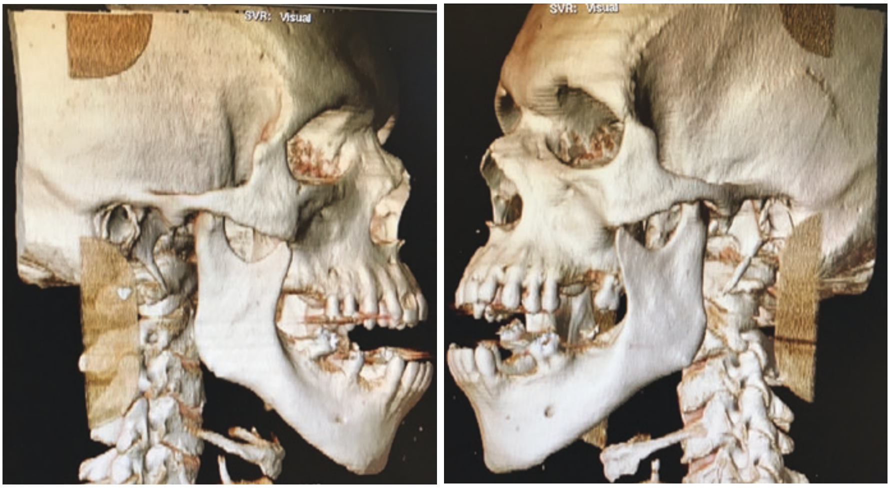

Fig. 4.5 3D reconstruction of bilateral chronic protracted dislocation

- Often needs IV sedation or general anesthesia as a result of pain and muscle spasm.
- Manual reduction of chronic protracted dislocation is rarely successful [6].

Manual reduction with traction

- Various authors have described techniques utilizing traction at different mandibular sites to assist with manual reduction.
- Intermaxillary fixation with posterior elastics has been described in order to provide posterior traction to the mandible [7]. The use of botulinum toxin to paralyze the masseter and temporalis muscle may be used to facilitate this process [8].
- Posterior bite blocks can be placed to stretch the muscles and ligaments to allow for easier reduction.
- Extraoral submandibular incisions and dissection to the angle of the mandible, followed by placement of intraosseous wires at the angle of the mandible, to assist with manual reduction and manipulation [9].
- A ramus stripper placed at the sigmoid notch can also be used to provide downward traction to the mandible (Fig. 4.6).
- A bone hook can be placed under the chin and pulled upward to stretch the soft tissue envelope [10].
- Manual reduction of chronic protracted dislocation may still be challenging despite traction.

Open surgery

The goal of open surgery is to reduce the dislocation and prevent recurrence [9]. Several varying surgical procedures have been advocated. There remains little evidence-based medicine to guide the decision-making process. Arch bars and class

Fig. 4.6 Ramus strippers placed in the sigmoid notch (Adapted from Huang IY, Chen CM, Kao YH, Chen CM, Wu CW. Management of long-standing mandibular dislocation. Int J Oral Maxillofac Surg. 2011 Aug;40(8):810–4)

III elastic bands are often needed, in addition to the surgical procedure, to adequately reduce the condyle/disc complex into the appropriate position in the glenoid fossa. This process may take several weeks.

Myotomies

- Fibrosis and shortening of muscles of mastication play a large role in the difficulty of reducing a chronically dislocated TMJ.
- These can be performed prior to attempts at open surgery [10, 11].
- Intraoral vertical buccal incisions with stripping of the masseter, medial pterygoid muscles from the ramus and body, stripping of the lateral pterygoid muscle from the condyle, and either coronoidectomy or stripping of the temporalis muscle [10].
- Myotomies can assist with manipulating the condyle beneath the articular eminence into the fossa.
- Periarticular fibrosis may still prevent the condyles from translating posteriorly into the fossa.

Midline osteotomy

- Technique described by Lee et al. in which a midline osteotomy is performed to allow the reduction of each condyle separately without interference from the contralateral side.
- After closed reduction of the condyles, the midline osteotomy is reduced and secured with two miniplates, and the patient is placed in maxillomandibular fixation for 10 days [12].

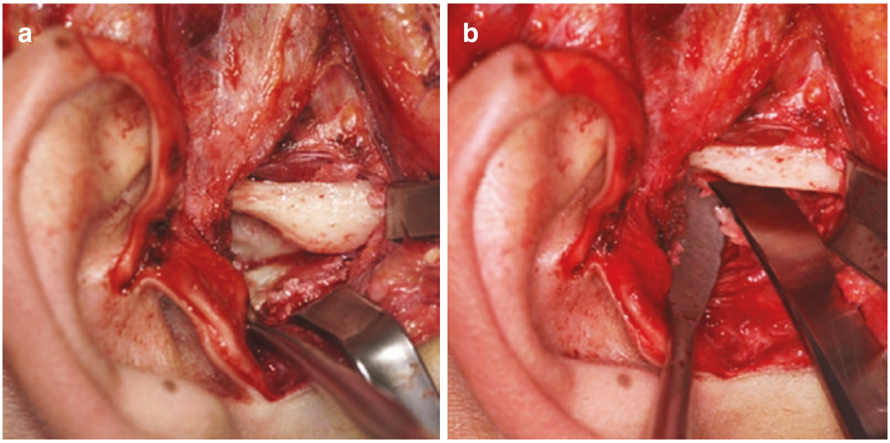

Fig. 4.7 Eminectomy (Adapted from Undt G. Temporomandibular Joint Eminectomy for Recurrent Dislocation. Atlas Oral MaxilloFac Surg Clin N Am 2011; 189–206)

- May still be unable to reduce the dislocation, as neither the joint nor muscle fibrosis is addressed with this procedure.

Joint exposure and manipulation of joint components [7]

- This allows for division of the joint capsule and direct manipulation of the condyle and disc with instruments.
- May still be unable to reduce the dislocation as the muscle fibrosis is not addressed.

Condylectomy [7]

- This reduces the condylar height allowing the condylar stump to slide beneath the articular eminence.
- Results in significant iatrogenic joint destruction.
- May result in a malocclusion.

Eminectomy (Fig. 4.7)

- Removing the articular eminence eliminates the mechanical barrier to dislocation.
- Facilitates reduction of the condyle into the fossa [13].
- Initial corticotomy through all but the most medial aspect of the eminence with a fissure burr, followed by judicious use of a chisel to complete the osteotomy [14].
- Final contouring with a reciprocating rasp once adequate space is created after the eminectomy.
- Disc plication is often also indicated given the laxity of the bilaminar zone following protracted dislocation.

Fig. 4.8 Postop panoramic X-ray of patient in Figs. 4.3, 4.4, and 4.5 following eminectomy and placement of guiding elastics

- Should be combined with arch bars and class III elastic bands for traction, to allow complete translation of the condyle into the glenoid fossa (Fig. 4.8).

Ramus osteotomies

- When reduction cannot be achieved, traditional mandibular osteotomies such as the sagittal split osteotomy and the vertical ramus osteotomy can be utilized to correct the resulting malocclusion [13].
- This results in a permanent pseudo-joint.

Total joint replacement

- Final treatment option when all other steps fail [13].
- This results in a functional joint but may not correct the malocclusion if the mandible cannot be adequately manipulated secondary to periarticular and muscle fibrosis.

4.5 Complications

Complications following the treatment of chronic protracted dislocation depend to a large extent on the procedures involved. Most complications can be considered to fall into one of the following categories:

- Failure of reduction
- Recurrence
- Malocclusion

- Facial nerve injury
- Hemorrhage
- Degenerative joint disease

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Conservative Management Options for Dislocation of the Temporomandibular Joint

5

Ross O.C. Elledge and Bernie Speculand

5.1 Introduction

Dislocation of the TMJ affects a wide demographic (up to 5% of the population) and can be attributed to a wide variety of causes including excessive mouth opening (e.g. yawning, vomiting, seizure), trauma (e.g. flexion-extension injury to the mandible, intubation, endoscopy, dental extraction), connective tissue disorders (e.g. Ehlers-Danlos syndrome, Marfan's syndrome) and psychogenic causes (e.g. habitual dislocation, tardive dyskinesia) as possibly the majority of cases [1]. Single episodes of TMJ dislocation are often managed by manual reduction techniques (discussed elsewhere in this text) and require no further intervention. The terms "chronic", "chronic recurrent" and "habitual" are interchangeable and used for cases in which repeated episodes of dislocation occur [2]. Other authors distinguish "acute", "chronic" (i.e. persistently dislocated) and "recurrent". Recurrent dislocations can be particularly troublesome and are the subject of discussion in the current chapter, which deals with conservative interventions to address these problems.

Recurrent dislocation of the TMJ in particular is often seen in elderly patients with cerebrovascular disease, epilepsy, dementia or dystonia due to comorbidities and/or as a side effect of medications [1, 3, 4]. Guven [2] classified such recurrent dislocation into five different types:

1. Few previous episodes and condyles repositioned without anaesthesia
2. More than a few episodes and condyles repositioned with local or general anaesthesia

R.O.C. Elledge • B. Speculand (✉)
Department of Oral and Maxillofacial Surgery, University Hospitals Birmingham NHS Foundation Trust, Queen Elizabeth Hospital, Edgbaston B15 2TT, West Midlands, UK
e-mail: speculand@googlemail.com

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3. More than a few episodes due to systemic disorder requiring surgical reconstruction
4. Previous failed surgical treatments requiring surgical reconstruction
5. Patients unable to receive intermaxillary fixation due to local/systemic problems

Such causes of habitual TMJ dislocation are often the very reasons that preclude more invasive treatment strategies for these patients, where general anaesthesia and surgery may be hazardous and undesirable. These considerations have contributed to the search for more conservative treatment strategies that are discussed here.

5.2 Autologous Blood Injection

Autologous blood injection (ABI) presents a number of advantages including ease of performance, low cost and low complication rates and has recently experienced something of a resurgence in interest [5]. The protocol described by Machon et al. [6] uses 3 mL of autogenous blood, 2 mL being injected into the upper joint space and 1 mL to the pericapsular region. The importance of injecting into the pericapsular tissues has been highlighted by Yoshida et al. [7], who demonstrated higher success rates when compared with injections into the joint space alone. The procedure may or may not be preceded by arthrocentesis and is undertaken typically under conscious sedation or general anaesthesia. Patients may be advised post-operatively to restrict mandibular movement and keep to a soft diet, with some authors also recommending a head dressing to limit mandibular excursions [8].

The principle behind the technique is the inciting of a physiological response of inflammation and oedema with resultant reduction in joint motion. Histological evaluation of a porcine model by Gulses et al. demonstrated fibrotic changes in the capsule and retrodiscal tissues [9]. Inflammatory mediators released by platelets cause vasodilatation and oedema of the periarticular tissues, diminishing compliance of the joint and reducing mobility. Organized clot leads to joint stiffness over time with maturation of fibrous tissue [9]. Magnetic resonance imaging (MRI) demonstrates accumulation similar to joint effusion from 1 h after ABI with progressive reduction in condylar movement on imaging at 12 weeks [10]. Success rates of 72.7–80% have been reported, although a concomitant reduction in mouth opening is routinely described [5–8]. Concerns have been raised about the risks of joint destruction, cartilage degeneration and chondrocyte apoptosis [11]. Exposure of cartilage to blood reduces chondrocyte metabolism and may elicit concerns for safety of the procedure in younger patients. In particular, it has been demonstrated that intra-articular blood can result in the induction of chondrocyte apoptosis, potentially leading to cartilage degeneration and ultimately joint destruction [12]. The evidence base for ABI is small and reliant on single-centre case report and series, but it is gaining favour once again.

5.3 Intermaxillary Fixation

Intermaxillary fixation (IMF) may be used alone or in combination with methods such as ABI, sclerosant injection or botulinum toxin type A for TMJ dislocation [13, 14]. As a stand-alone technique, a period of immobilization for 3–6 weeks is recommended, although results are disappointing with higher recurrence rates than those seen with other conservative management strategies [14]. There is evidence to suggest that combined strategies with other treatments may achieve the highest success rates overall. IMF techniques employed may include eyelet wires, circum-mandibular wires, arch bars, orthodontic brackets, Leonard buttons, IMF screws and hybrid MMF systems. Methods have also been described to use IMF to relocate the condylar heads following protracted periods of dislocation, using acrylic bite blocks in the molar region as a fulcrum in concert with class III elastics applied to arch bars and IMF screws [15].

Intermaxillary traction with elastics is of particular value in the management of chronic protracted TMJ dislocation, as opposed to chronic recurrent dislocation or habitual dislocation. In these instances, there can be considerable difficulty in overcoming spasm of the pterygomasseteric sling, temporalis muscle fibrosis and impingement of the coronoid process, and traditional methods of manually relocating the TMJ such as the Hippocrates manoeuvre will often fail. A combination of posterior bite blocks and class III elastic traction on arch bars has been described as successfully reducing isolated cases over a period of weeks [16].

5.4 Botulinum Toxin

Botulinum toxin is produced by the anaerobic bacterium *Clostridium botulinum* and acts by blocking the release of acetylcholine into the synaptic cleft at the motor end plate, thus interrupting neuromuscular transmission. Licenced indications for medical use in the United Kingdom are varied and include strabismus, blepharospasm, hemifacial spasm, cervical dystonia, focal spasticity in cerebral palsy, upper limb spasticity in adult stroke patients and axillary hyperhidrosis [17]. The use of botulinum toxin for TMJ dislocation is an unlicenced indication and was first described by Daelen and colleagues [18].

For recurrent TMJ dislocation, botulinum toxin type A is injected extraorally through the sigmoid notch into the lateral pterygoid muscles bilaterally (Figs. 5.1 and 5.2), with or without concomitant injection into the masseter muscles bilaterally [19]. An intraoral route of injection has also been described by some authors, although this is less commonly reported [20, 21]. Electromyographic (EMG) control can be used to facilitate a more accurate injection [22, 23]. The senior author has also often injected the anterior fibres of the temporalis muscles, as the vector of pull of these fibres may serve to contribute to protrusion of the mandible and a predisposition to condylar dislocation.

Fig. 5.1 Injection of Botox® through the sigmoid notch into lateral pterygoid muscle schematically represented on a stereolithographic model

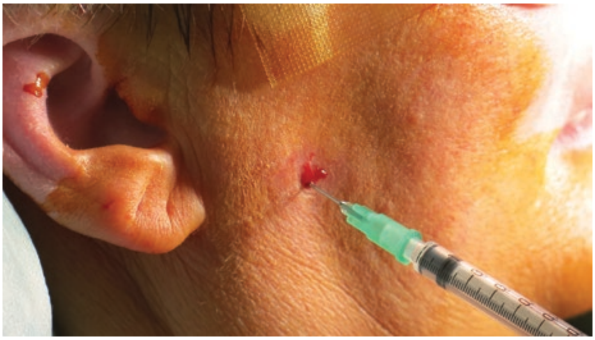

Fig. 5.2 Injection of Botox® through sigmoid notch into lateral pterygoid muscle demonstrated on a patient

Doses are variable, but typically when using Botox® (Allergan), 25–75 U are injected into each side. Importantly, units of Dysport® are not equivalent to units of Botox®. Dysport® is around four times less active than Botox®, and doses should be adjusted accordingly, although the literature generally describes the use of Botox® [17]. Typical doses for Dysport® as used by the authors are around 500 U into each muscle.

As with many of the options discussed in this chapter, evidence is sparse and confined to case series of small numbers. The largest cohort in the literature that we could find is that of Ziegler and colleagues [4], who demonstrated complete cure of recurrent TMJ dislocation in 19 out of 21 patients over a follow-up time of up to 3 years. Adverse effects are infrequent, with the most common being transient dysphagia in 8% of patients as the result of diffusion of the drug into adjacent muscles [20]. Other potential side effects include nasal regurgitation, nasal speech, painful chewing and dysarthria [20]. Careful injection technique and appropriate dosing should minimize these problems that are short-lived when they do occur. Risks must be discussed and documented, and written informed consent provided to encompass those risks mentioned, as well as the possibility of transient facial weakness which may persist for months due to inadvertent distribution of the toxin adjacent to branches of the seventh cranial nerve.

5.5 Exogenous Sclerosants and Prolotherapy

A wide variety of exogenous sclerosants has been tried including iodine, ethanolamine oleate, alcohol (100% ethanol), bleomycin, tetracycline, cyclophosphamide and OK-432 (Picibanil), among others [3]. The senior author has also successfully employed sodium tetradecyl sulphate (STS), more widely used in the management of venous varicosities as a sclerosant.

The use of intra-articular sclerosant has been a part of the armamentarium for dealing with recurrent TMJ dislocation for some time and was first described as early as 1950 by McKelvey [24]. Whilst various agents have been tried, most recently OK-432 has been highlighted by Matsushita and colleagues as a possible agent of choice [3]. The drug is a streptococcal derivative inactivated by penicillin G. Originally developed as an anticancer agent, maxillofacial surgeons are often more familiar with its use in treating lymphatic malformations and chyle leaks following neck dissections [3, 25]. Prepared by diluting the drug with equal parts of saline and 2% lignocaine, it can be introduced into the superior joint compartment and pericapsular tissue. The authors highlighted two cases that exhibited no further episodes of dislocation at 6 months but acknowledged the risks of anaphylaxis, interstitial pneumonia and acute renal failure.

"Prolotherapy" is a variation on this theme that involves the intra-articular injection of non-sclerosants such as dextrose to initiate an inflammatory response. Zhou and colleagues [26] described the use of 50% hypertonic dextrose with 2% lignocaine as an intra-articular injection in 45 patients suffering from recurrent dislocation. Success was achieved in 91% of cases by 12 months, although a few of the patients received more than one round of treatment during that period. A small randomized controlled trial conducted by Refai et al. [27] showed promise in the use of prolotherapy for TMJ hypermobility, although they used 10% dextrose with 2% mepivacaine, and the follow-up period was much shorter (12 weeks).

5.6 Mental Health and Recurrent TMJ Dislocation

There is no doubt that in a subset of patients with recurrent or habitual dislocation of the TMJ, there is a functional component to all or part of their presentation, with an overlap between mental health disorders and TMJ dislocation. A substantial portion of patients with chronic TMJ disorders have been shown to have moderate to severe depression with somatization in cohort studies [28, 29]. Furthermore, mental health patients taking neuroleptic medications or antipsychotics have been shown to develop TMJ dislocation as a result of dystonia secondary to their medications [30–32]. Converting patients to different medications or seeking different treatment modalities may have a role to play in reducing episodes of habitual dislocation in such patients, and clinicians should work closely with the psychiatric services responsible for their care.

Orofacial pain and TMJ disorders have been reported as being far more common in patients with eating disorders, particularly those patients exhibiting binge eating and self-induced vomiting [33]. In one study, eating disorder patients practising self-induced vomiting were shown to have higher muscle sensitivity on palpation alongside expected higher rates of dental erosion and attrition, and these clinical findings are worth noting [34].

Perhaps more worryingly is the trend for some patients to deliberately induce recurrent subluxation or dislocation of the TMJ as part of attention-seeking behaviour or Munchausen syndrome [35]. Such patients may present on a regular basis to emergency departments and become well known to local maxillofacial services. Named after the Baron von Munchausen and his fantastical stories, Munchausen syndrome is said to be characterized by a triad of pathological lying, simulated illness and wandering from hospital to hospital (peregrination) [36]. In such patients, the emphasis should be on "compassionate and firm limits" to the level of care provided, and clearly in such a group, conservative and non-surgical treatments are likely to be the ceiling of care [35]. It is important that all members of the team are aware of such patients and are consistent in their communication.

We have encountered a small number of younger patients who were referred to us with recurrent TMJ dislocation, either unilateral or bilateral, in whom it eventually became evident that there were underlying psychological issues which merited referral on to clinical psychologists or psychiatrists. These issues concerned bereavement reactions, issues of conflict with one or both parents and complex psychological and metabolic problems akin to anorexia, the latter compounded by periods of intermaxillary fixation. We have failed to find any studies in the maxillofacial or psychiatric literature exploring these issues.

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6 Surgical Management: Clearing the Path

Andrew J. Sidebottom and Sujeev Rajapakse

The hierarchies of management objectives for recurrent TMJ dislocation are to cause no harm, restore function and restore anatomy. More conservative options should be considered prior to surgical intervention such as dextrose prolotherapy, autologous blood injection or botulinum injections described elsewhere in this text. Both stability and range of movement of the TMJ are dictated by:

- The occlusion (or lack of it)
- Shape of the glenoid fossa including the slope and size of the articular eminence
- The TMJ capsule—a thickening of the deep fascia, being strongest laterally
- The TMJ ligaments—sphenomandibular and stylomandibular

The normal range of movement is from 35 to 40 mm between the incisal edges and 7–10 mm lateral excursion and protrusion.

Once a dislocation has occurred, there is thought to be stretching of ligaments, allowing further dislocations to occur more easily. The aims of surgical intervention are therefore to either prevent further dislocations, blocking procedures, or to prevent the joint becoming stuck in front of the eminence, reduction procedures. The remainder of this chapter will consider the latter; however, it is important to try to reconstruct the joint ligaments and tighten the capsule at the same time to provide added stability and a degree of restriction.

It has been observed that a deep overbite is also frequently associated with a deep glenoid fossa and a steep articular eminence, which is thought to be conducive to

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A.J. Sidebottom (✉) • S. Rajapakse
Nottingham University Hospitals, Nottingham, UK
e-mail: ajsidebottom@doctors.org.uk

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dislocation [1]; hence, the suggestion that reducing the eminence may be a solution to the prevention of recurrent dislocation.

The original description of eminectomy is ascribed to Myrhaug [1], and the procedure is often called the Myrhaug procedure.

6.1 Ligament Modification

Intermaxillary fixation (IMF) was thought to help with ligament healing [2], but no long-term benefits have been proven.

There are no studies to demonstrate the long-term success of capsular plication [3] which requires entry into the joint space and the risk of degenerative changes. This procedure can be carried out arthroscopically (capsulorrhaphy) with some success using the holmium Nd:YAG laser. In those cases (20%) where this failed, open surgery was advocated [4].

Ligamentorrhaphy involves suturing the lateral aspect of the TMJ capsule to the zygomatic arch. A very small case series showed good success when used with lateral capsular plication and 1 week post-operative IMF [3].

Other reinforcement procedures used in conjunction with ligamentorrhaphy include:

- Mitek anchors with heavy sutures passed to act as restraining "ligaments" at the lateral pole of the condyle and posterior root of the zygomatic arch [5].
- Temporalis fascia can be used in a similar manner combined with bony augmentation of the eminence [6].
- Tightening of the lateral ligament in combination with eminence reduction [7].

These procedures may be used in conjunction with other procedures to limit range of motion or improve the ability to self-reduce.

6.2 Bony Modification

Bony modifications are either aimed at augmenting structures that obstruct the path of the condyle, thus preventing dislocation of the TMJ, or reducing/removing structures that prevent reduction of the dislocated condylar head.

6.3 Eminectomy

Whilst this is considered the standard procedure to deal with recurrent dislocation in the UK, the theory as to how it works has been challenged based on procedures carried out arthroscopically (see later). Eminectomy itself, considered an extra-articular procedure, requires the removal of significant depth of bone to at least 2 cm. This carries the risk of damage to deeper structures, and in inexperienced hands, misdirection of the cut can carry the osteotome or burr superiorly and into the intracranial fossa. Similarly, a significant proportion of patients have air cells in the articular eminence (2–5%), and it is therefore advisable to consider a CT scan to exclude these

Fig. 6.1 Air cells visible in the articular eminence (*black dots*) on this 3D CAD-CAM model

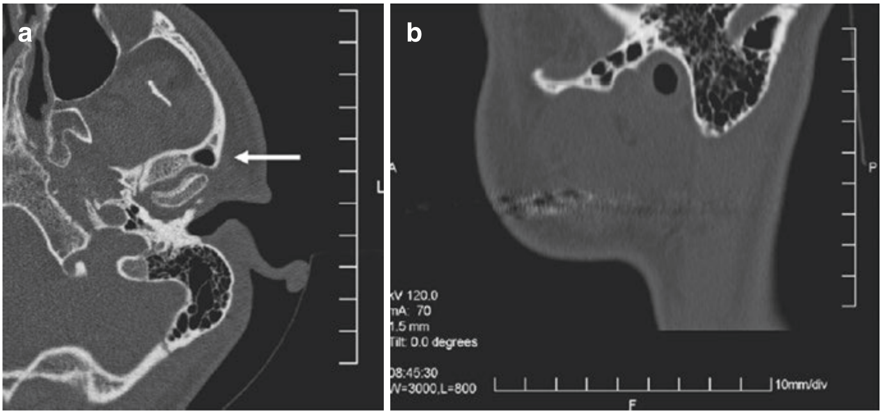

Fig. 6.2 CT scan revealing air cells in the eminence (**a**) coronal (**b**) axial (Courtesy Prof. N. Shaun Matthews)

prior to considering this option. Damage to the air cells may increase the risk of bacterial access to the joint from the associated mastoid sinuses (Figs. 6.1 and 6.2).

Standard access to the joint is obtained with subperiosteal exposure of the arch and eminence [8]. Dunn-Dautrey retractors are placed on either side of the eminence in the subperiosteal plane protecting the intraarticular disc. The author prefers to use a burr, but the use of an oscillating rasp has been described [9]. The lateral eminence is postage stamped and the holes joined to penetrate the cortex. A straight osteotome is then gently tapped in a horizontal direction until the bone cut is completed. The fragment is then removed, the area irrigated, and the wound closed in layers in the usual fashion (Fig. 6.3a–d). Prior to closure, it is often worthwhile to perform a limited disc plication and capsulorrhaphy to tighten the tissues around the joint. Drainage is not usually required and this procedure can often be completed as a day case.

Gentle active mobilisation is encouraged at 2 weeks post-surgery.

A video of the procedure can be seen performed using a Piezotome by the textbook author Prof. N. Shaun Matthews.

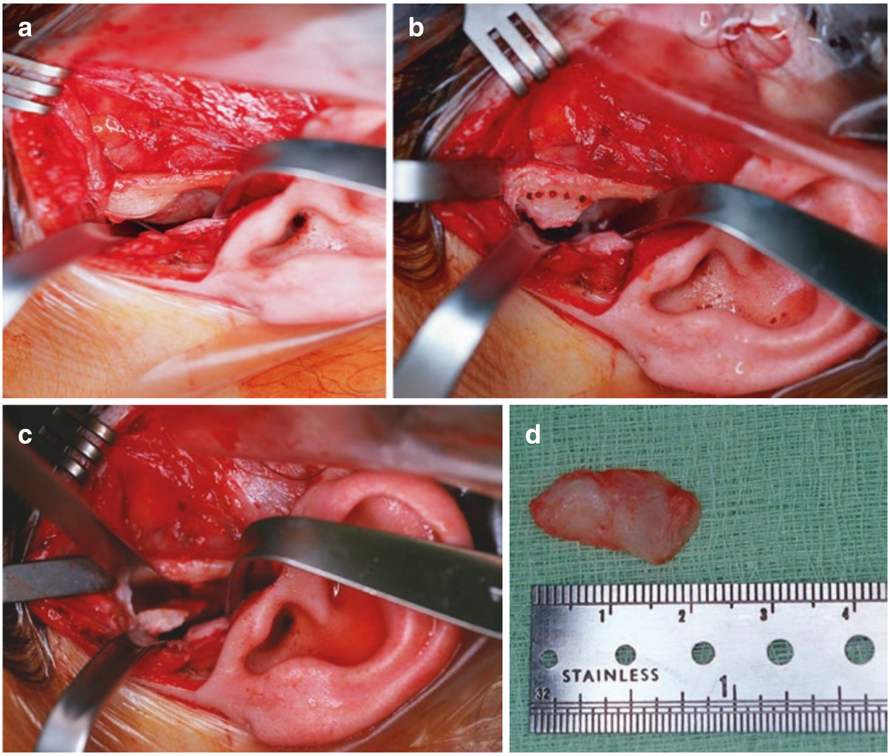

Fig. 6.3 Eminectomy procedure. (**a**) Protection of the intra-articular structures with the Dunn-Dautrey retractors. (**b**) Postage stamp of the eminence. (**c**) Removal of the eminence with an osteotome. (**d**) 2 cm depth of removed eminence

It is the authors' experience that this procedure carried out in the growing patient can have a regrowth of the eminence over time and therefore, a recurrence of the dislocations after a few years. The work of Undt [10] has also shown that a more limited procedure involving only reduction of the lateral one-third of the eminence is sufficient, and it is felt that the efficacy of the procedure is as much due to intra-articular fibrosis (and limitation of movement) in the anterior recess, as it is to reducing the eminence and preventing the condyle becoming stuck. Certainly, arthroscopic examination of a joint where eminectomy has previously been performed shows this to be the case, with a clear posterior zone and marked fibrosis in the anterior zone.

6.4 Eminoplasty

The open version of this procedure is carried out similar to an eminectomy, and it is the authors' feeling that true eminectomy is rarely performed, just various degrees of eminoplasty. The lateral one-third (6–8 mm) of the eminence is reduced in a similar manner with less risk of damage to the disc, brain and deeper structures. This procedure can also be performed arthroscopically using a microabrader [11], dispelling the myth that eminectomy is an extra-articular procedure. At the same time, the disc can be sutured or the retrodiscal tissues lasered or diathermied [12] to tighten them in a similar manner to capsulorrhaphy. This procedure can only be performed by surgeons with significant expertise in arthroscopy and requires specifically designed instruments and two portal accesses to the joint.

Success rates of both procedures range from around 80 to 90% [10]. Complications are minimal and usually related to transient weakness of the temporal branch of the facial nerve. Long-term complications have not been reported; however, there may certainly be a risk of developing degenerative joint disease due both to the damage caused by the recurrent dislocations prior to surgery and the iatrogenic damage of the surgery itself. Similarly, there are limited reports of long-term success beyond 5 years, and it may be that the ligamentous laxity in youth spontaneously tightens the structures further, as inelasticity develops with age.

A thorough discussion of these techniques and summary of the literature is provided in the excellent article by Professor Undt [10] to which the reader is referred for further information on techniques and post-operative function of the joint.

A meta-analysis of the efficacy of all types of procedures used to treat recurrent dislocation came up with no definitive conclusion due to the poor scientific quality of all the papers on the subject; most are case reports and case series [13]. The authors did however suggest that the "go-to" procedure when all else failed was eminectomy for most surgeons.

Conclusion

Reduction of the eminence is a simple procedure which should be within the armamentarium of any maxillofacial surgeon dealing with temporomandibular disorders. It is safe and technically nondemanding. The surgeon should be aware of the risks associated with aiming too high medially with the osteotomy cuts and the possibility of mastoid air cells extending into the articular eminence. Similarly, one should not be unduly concerned about extending the resection too far medially, as the results are similar with a limited eminoplasty.

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7 Surgical Management: Obstructing the Path

Mathilde Sarlabous and David J. Psutka

7.1 Introduction

Dislocation of the temporomandibular joint (TMJ) can involve one or both condyles and represents 3% of all reported dislocated joints in the body [1]. Most cases occur bilaterally. TMJ dislocation occurs in up to 7% of people during their lifetime [2]. The condyles may be displaced anterior, posterior, medial, lateral, or superior to the condylar fossa, but anterior dislocation is the most common [3]. In these cases, condyles are suddenly displaced anteriorly, beyond the articular eminence.

Dislocation of the temporomandibular joint can be categorized into three groups: acute, chronic recurrent, and long standing [4]. Acute dislocation is the most common. Reduction of the acute luxation should be done quickly before muscle spasm becomes severe and makes the procedure more difficult. This necessitates a downward and backward manipulation to reposition the condyles back in place.

In chronic recurrent dislocation, episodes of dislocation are more frequent and severe enough to suggest a more interventional approach. Identification of etiology is important when considering surgical correction. No consensus exists regarding the most effective treatment for chronic recurrent TMJ dislocation. Many nonsurgical and surgical treatments have been proposed over the years. This illustrates the difficulty that has been experienced in producing a satisfactory method for the treatment of chronic recurrent dislocation. Accurate comparisons of the reported surgical modalities are difficult because of differing follow-up, different definitions of success, and the small number of patients included in studies. Dislocation of the TMJ is quite rare, and the scientific literature lacks randomized, prospective

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M. Sarlabous, DMD, MSc, FRCD(C) • D.J. Psutka, DDS, FRCD(C) (✉)
Mount Sinai Hospital Center for Excellence in TMJ Reconstructive Surgery, Toronto, Canada
e-mail: davidjpsutka@rogers.com

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controlled studies. Nevertheless, authors agree that postoperative scarring probably provides a significant portion of the surgical benefit.

Nonsurgical options include medications (muscle relaxants, antispasmodic medication), psychological management, physical therapy, intermaxillary fixation, bandage and splints, injection of sclerosing agents into the TMJ capsule, TMJ ligament and bilaminar tissue scarification (with or without using arthroscopy), and botulinum toxin muscular injections.

Surgical options can be divided into five categories: soft tissue procedures, removal of obstruction (eminectomy), creation of a mechanical obstacle, tethering techniques, and mandibular osteotomies (condylotomy, high condylectomy, vertical oblique osteotomy) [5].

This chapter will focus on treatments obstructing the condylar path.

7.2 The Dautrey (LeClerc) Procedure

Zygomatic arch down-fracture (LeClerc or Dautrey procedure) is a well-known and popular surgical technique for treatment of recurrent dislocation [6, 7]. Mayer in 1933 was the first to advocate the surgical displacement of a portion of the zygomatic arch inferiorly to block excessive translation of the TMJ condyle [8]. In 1943, LeClerc and Girard improved the technique when they described a method whereby a thicker portion of the zygomatic arch is osteotomized and down-fractured, in order to block excessive translation of the mandibular condyle. The procedure was modified by Dautrey and Gosserez in 1967.

Access is gained through a preauricular incision with a temporalis extension. Along the temporalis fascia, the zygomatic arch and the capsule of the temporomandibular joint are easily reached. The fascia and periosteum are incised at the root of the zygoma. Care should be taken not to strip the fascia and periosteal attachment from the anterior portion of the zygomatic arch to prevent a true fracture at the zygomaticotemporal suture [9]. An oblique osteotomy is made (downward and forward), immediately anterior to the eminence. The method of elevation of the arch is of importance: the arch is first laterally displaced and then moved inferiorly to be locked under the eminence. A greenstick fracture is performed at the zygomaticotemporal suture. The arch is kept in position by the inherent elasticity of the bone (Figs. 7.1 and 7.2). Some authors perform fixation at the osteotomy site with plates and screws or wires. Maxillomandibular fixation (MMF) is not necessary for postoperative stability.

Some authors suggest that the fractured zygomatic arch must be placed so far medially, to engage the condylar head. This is of importance with small condylar heads which can pass anteromedial to the down-fractured arch [11].

Studies show that the Dautrey procedure does not interfere with normal function of the TMJ but prevents abnormal forward excursion of the condyle [9, 12]. Recurrence is rare and excellent results have been reported [6, 13]. This procedure may be advantageous in that it does not violate the joint space and allows immediate movement with little limitation in maximal opening.

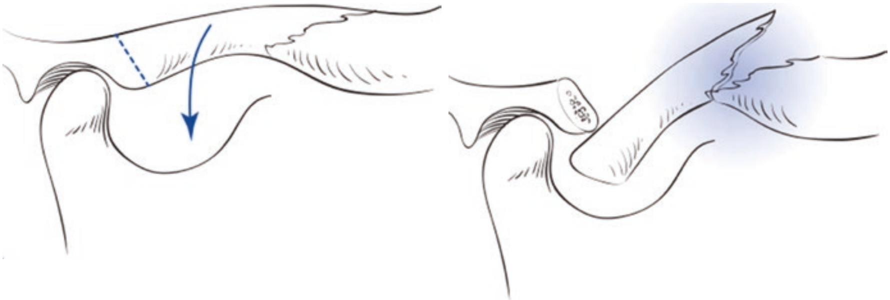

Fig. 7.1 Dautrey procedure. An oblique osteotomy is created anterior to the articular eminence. The posterior down-fracture allows the arch to be locked under the eminence [10]

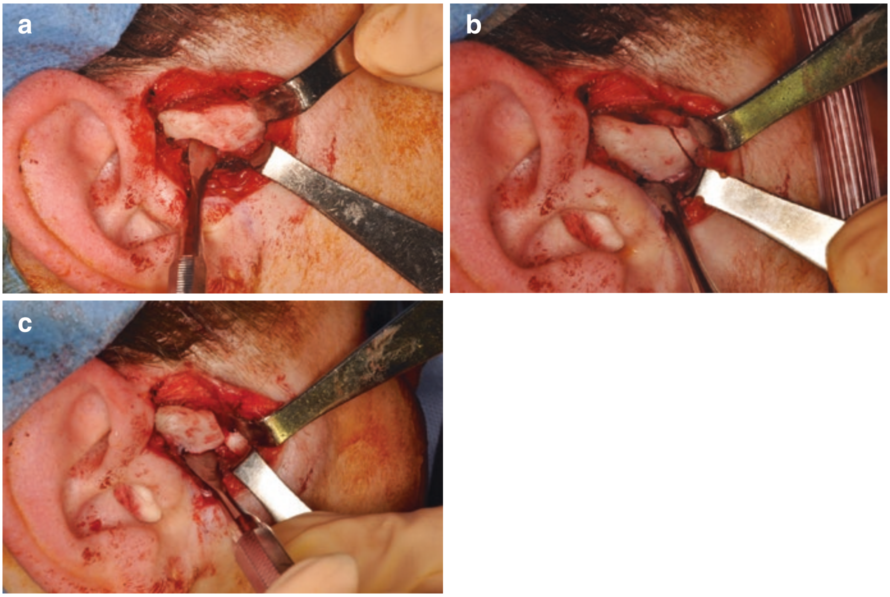

Fig. 7.2 Clinical pictures of the Dautrey procedure. (**a**) Exposure of the arch, (**b**) osteotomy just anterior to the eminence, (**c**) down-fracture of the arch (Courtesy Dr. Carl Bouchard)

The major risk is a complete arch fracture which may require bone plate or wire fixation [14]. Care must be taken in elderly patients (after age 40) because of brittleness of the bone.

Other complications are related to the preauricular approach, including facial nerve weakness and paresis, infection, bleeding, preauricular scar and skin numbness along the auriculotemporal nerve distribution.

Resorption of the down-fractured eminence can lead to dislocation recurrence [15]. Bone resorption and remodeling were noted radiographically on follow-up studies [12]. Some authors have also reported the risk of the fragment relocating.

Fig. 7.3 Pictures demonstrate a large air cell within the zygomatic arch (*arrows*)

Pneumatization of the articular eminence of the temporal bone may turn a relatively simple procedure like eminectomy into a greater surgical challenge due to the risk of dural tear or fracture of the arch [7] Fig. 7.3. Computed tomography scanner (CT scan) has great diagnostic accuracy in the evaluation of temporal air spaces. The Dautrey procedure can be performed with care on a pneumatized arch.

Overall, a cure rate of 91% was reported with the Dautrey procedure with a recurrence rate of 9% [1].

Take-Home Messages for Dautrey Procedure

- Extracapsular procedure.
- Good success rate with low recurrence rate.
- Risk of arch fracture in elderly patients.
- Radiological preop assessment is required for arch pneumatization.

7.3 Articular Eminence Grafting Procedures

Increasing the articular eminence height with an interpositional graft is another popular procedure to obstruct the path of condylar movement. Several materials have been suggested over the years like hydroxyapatite (HAP), silicon elastomer (Silastic), and autogenous bone.

Mayer, in 1933, was the first to publish on three patients in whom a block of bone, obtained from the zygomatic arch, was wedged into the articular eminence [16].

Karabouta described an inverted “V” bone osteotomy made on the eminence with an incomplete down-fracture to create a gap where pieces of hydroxyapatite were inserted [17]. Good results have been obtained in this study. Nevertheless, displacement and infection of HAP and silicon implant have been reported, as well as foreign body reactions, and these materials are no longer used [1, 3].

The Norman’s procedure (glenotemporal osteotomy) has also been described [18–20]. The preauricular approach is the same as in the Dautrey procedure, and the dissection is extracapsular. The articular eminence is exposed keeping the soft tissues attached to its lower and inner portion to avoid resorption. A horizontal osteotomy measuring at least 1.5 cm deep separates the articular eminence from the zygomatic arch. A fine osteotome is used to separate the eminence from the zygomatic arch, and the gap created measures approximately 3–5 mm. A bone graft harvested from either the iliac crest or the calvarium can be interposed in the gap. Sufficient space must be left in front of the condyle so that it can rotate freely during mouth opening. The graft is secured with a microplate or a wire. The small plate functions as a mechanical obstruction to anterior condylar movement, particularly if the graft resorbs [15]. As with the Dautrey procedure, there is a risk of zygomatic arch fracture, and care should be taken in patients over 40 years old.

Glenotemporal osteotomy with interpositional bone grafting not only increases the height of the articular eminence but also its width, avoiding the medial escape of the condyle.

Autogenous bone grafts obtained from the zygomatic arch, mastoid process, chin [21], iliac crest, and calvarium are some of the options to increase the eminence height [22]. Autogenous bone grafting necessitates a second surgical site with associated potential morbidity of the donor site. Harvesting cranial bone from the temporoparietal area can be performed by extending the preauricular incision. Nevertheless, this bone is thin, and the area is at risk of serious complications (dural tears, arachnoid bleeding, scalp infections, and hematoma) [3]. Iliac crest graft provides a good volume of bone with good osteoinductive and conductive capacity but has a certain tendency toward resorption.

Norman's procedure has also been used in one patient with interposition of a xenograft [23]. In their study, the author used Chondroplast® (processed bovine cartilage) with good results. The rationale was to avoid morbidity of a donor site and graft resorption. The length of follow-up was not indicated.

Kummoona described a surgical technique to treat patients with recurrent TMJ dislocation [24, 25]. He used a concomitant inferiorly based finger like temporal fascial flap for the reconstruction of the lax capsule with a corticocancellous bone graft of the articular eminence. In this technique, a vertical osteotomy of the zygomatic arch was made just behind the eminence to create a 0.5 cm gap. The graft taken from the iliac crest was placed and impacted in the gap to act as an obstacle to prevent forward movement of the condyle.

In a similar way, Sharma also modified the Norman's procedure by adding an inferiorly based pedicled flap from the temporal fascia, sutured to the anterolateral aspect of the capsule [26]. The vertical osteotomy was performed just behind the articular eminence, creating a 0.5 cm gap. The gap was filled with a piece of corticocancellous bone taken from the iliac crest. No fixation was used. He also performed a concomitant intraoral pterygoid disjunction for cases where hypermobility was associated with painful temporomandibular disorders. The rationale behind pterygoid disjunction was to reduce the length/strength of the lateral pterygoid muscle, thereby providing rest to the joint.

Overall, either the zygomatic down-fracture procedure or interpositional graft probably acts initially as a mechanical block, but long-term success is generally thought to be as a result of formation of a surgical scar.

Take-Home Messages for Grafting Procedures

- Extracapsular procedure
- Risk of arch fracture in elderly patients
- Necessitates a graft harvest site
- Unpredictable bone resorption

7.4 Metallic Obstacles: Miniplates and Screws

Various heterogeneous materials have been used to restrict the condylar pathway: stainless steel pins, titanium plates and screws, and Vitallium mesh (alloy of Co-Cr-Mo).

In 1988, Buckley and Terry described a method of treating chronic mandibular dislocation using a bone plate fixed to the zygomatic arch, limiting condylar translation anteriorly [27]. At the same time, Kent refuted this technique, arguing that the plate may lead to trauma of the condyle and he reported a case in which Vitallium mesh fixed to the zygomatic arch caused the latter to fracture due to the constant pressure [28].

Metallic obstacles like miniplating of the articular eminence (eminoplasty) have been used successfully in selected cases. The articular eminence and zygomatic arch are approached by the conventional preauricular incision. Various plate designs have been described: T-shaped titanium plate [29, 30], L-shaped plate [28, 31], and custom-manufactured plate [32]. Some authors combine a hook-shaped plate with an autologous bone graft [33]. The graft is fixed to the free part of the miniplate with screws, and the plate is then fixed to the articular eminence.

The miniplate eminoplasty is a minimally invasive technique with low recurrence rate of dislocation, but there is still some controversy in the scientific literature regarding predictability and outcomes of the technique. Some authors report that hardware fracture appears as a relatively frequent complication (25%) [34], as well as resorption of the condylar head and articular eminence [35, 36]. The risk of miniplate fracture increases the chance of dislocation recurrence and requires a further operation for removal of the device.

In their long-term follow-up study on 20 patients, Kuttenberger et al. found that fracture of the miniplate occurred in seven patients, 3 to 7 years after the eminoplasty [37].

In 2009, Vasconcelos et al. published a comparative study between eminectomy and miniplates [31]. There were ten patients treated by eminectomy and eight by miniplates. The major complication found was unilateral miniplate fracture in two patients with secondary recurrence of dislocation in one of these patients. In their study, eminectomy was shown to be more efficient in the treatment of mandibular dislocation.

Titanium screw is another option to treat chronic mandibular dislocation [38]. In this article, the authors describe a minimally invasive technique for titanium screw placement in the articular eminence. Under local anesthesia, a 2 mm incision is made 2–2.5 cm below the articular eminence. A tunnel is created above the superficial musculoaponeurotic plane from the incision toward the eminence. A trocar is then introduced and its position confirmed with fluoroscopy. The tip of the trocar should be slightly upward and perpendicular to the most prominent part of the eminence. A hole is drilled and a 20 mm screw is placed. The patient is asked to open and close his mouth, and the screw position is checked with fluoroscopy. This technique is applicable when dealing with medically compromised patients or patients who refuse the surgical risks of a preauricular incision.

One study published in 2014 reported good success in 17 patients (27 joints) with chronic dislocation who underwent disc anchoring with an orthodontic mini-screw [39]. In this study, authors describe the difference between menisco-temporal and menisco-condylar dislocation, depending upon whether the dislocation occurs between the condyle-disc unit and the temporal bone (menisco-temporal) or between the disc and the condyle (menisco-condylar). Few procedures like meniscal plication, meniscopexy, and posterior tissue scarification primarily address a malpositioned disc in chronic dislocation (menisco-condylar luxation). If the magnetic resonance imaging (MRI) can prove the menisco-condylar dislocation, repositioning the disc can be a successful procedure. During surgery, a full wedge of retrodiscal tissue was removed. The disc was posteriorly repositioned and anchored to the mini-screw placed in the condylar head. During closure, a capsulorrhaphy or capsule-tightening procedure was performed to reinforce the joint capsule. This kind of procedure implies a more invasive approach, as this represents intra-articular surgery.

The use of Mitek® anchors for the treatment of chronic mandibular dislocation has also been described [5]. This is a tethering technique. Five patients were included in this study with a 2–4-year follow-up period. Two Mitek® anchors are used: one is placed in the lateral pole of the condyle and the other in the posterior root of the zygomatic arch. Heavy suture material is threaded through the eyelet of each anchor and tightened to function as a restraining ligament. This technique can be combined with articular disc repositioning if needed.

Take-Home Messages for Metallic Obstacles

- Extracapsular procedure
- Minimally invasive
- Risk of hardware fracture
- Risk of condylar head resorption

7.5 Soft Tissue Procedures

Soft tissue procedures have been practiced to alter joint motion. They include plication of the lateral capsule, detachment of the lateral pterygoid muscle from the condyle (lateral pterygoid myotomy), temporalis fascial flap to reinforce the weak lax capsule, suturing the articular disc anterior to the condyle (Konjetzny 1921), and scarification of the temporalis tendon. Deepening of the glenoid fossa by resection of the disc was also attempted for the first time by Ashhurst in 1921 [40]. Reports regarding soft tissue procedures for chronic recurrent TMJ dislocation remain rare in the literature.

7.5.1 Capsular Plication

In cases of extreme joint laxity, mechanical tightening of the capsule may be indicated. Plication procedures are aimed at limiting mandibular motion and may be accomplished in various ways [10]. The technique was first described by Morris in 1930 [41]. The capsule is approached via a preauricular incision. Removal of redundant capsular tissue can address laxity (Fig. 7.4). Several plication techniques have been described like the T-shaped incision [42], the reverse L-shaped incision on the lateral wall, and advancing the flap to support the anterior wall of the capsule [24] (Fig. 7.5). Nevertheless, capsular plications have been reported too rarely to be considered the mainstream treatment.

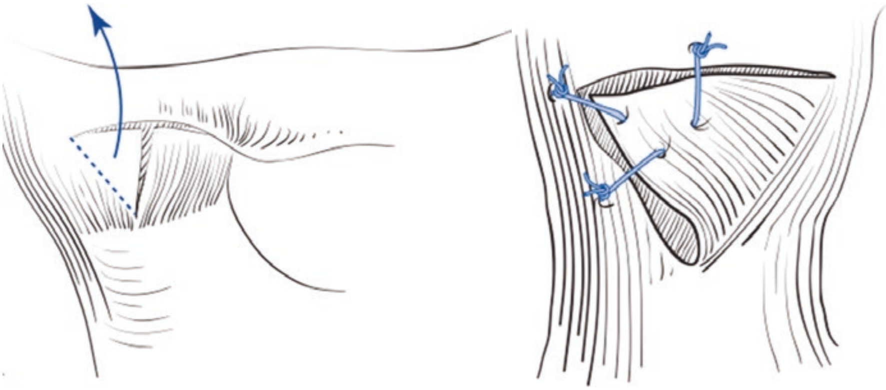

Fig. 7.4 Capsular plication. The exposed lateral capsule is incised and sutured back on itself to tighten and limit capsular laxity [10]

Fig. 7.5 Diagram showing the reverse L-shaped incision for plication of the lateral capsule [24]

7.5.2 Temporal Fascial Flap

Using a temporalis fascia flap to act as a new ligament was initially described by Nieden in 1923 [41]. In two studies previously cited in Sect. 3 of this chapter [24, 26], an inferiorly based finger-like temporal fascial flap for the reconstruction of the lax capsule, together with a corticocancellous bone graft from the iliac crest, was used in patients with recurrent TMJ dislocation. The flap was turned down and sutured to the anterolateral wall of the lax capsule. The flap prevents laxity of the capsule, reinforces the temporomandibular ligament, and further induces scar formation.

7.5.3 Lateral Pterygoid Myotomy and Temporalis Tendon Scarification

Myotomy was described for the first time by Bowman in 1949. The operation attempts to allow only rotational movement of the condyle, thereby limiting the translation.

In the lateral pterygoid myotomy described by Laskin in 1973, both insertions of the muscle are divided from the condylar neck and joint capsule and their reattachment is prevented by the insertion of a thin silastic sheet. This was performed by a preauricular approach [38].

Lateral pterygoid myotomy can also be accomplished by an intraoral approach via a vertical coronoid incision, followed by 7–10 days of MMF [43]. There is a risk of bleeding in this highly vascular site, and reattachment of the musculature during the healing process is difficult to control. It also has the potential to cause deviation of the mandible and occlusal disorders [44]. With the advent of botulinum toxin, pterygoid myotomy is no longer used.

Gould in 1978 described a method of shortening the temporalis tendon at its point of insertion along the ascending ramus, by scarification, to prevent excessively wide opening. In this procedure, the majority of the tendinous fibers are stripped from the ramus and sutured to the reflected periosteum and oral mucosa in a fashion that creates tissue disorientation and subsequent scar formation [1]. This procedure is highly technique sensitive, and no long-term studies have been conducted to establish its efficacy. Gould himself commented on a gradual tendency toward relapse at 1-year follow-up. No further references to this technique were found in the literature.

7.5.4 Tethering Techniques

In 1918, Blake described a method of limiting mouth opening by fixing the coronoid process to the zygomatic arch with wires [40].

Gordon in 1951 described a technique to treat recurrent TMJ dislocation by formation of a new external ligament using a strip of fascia lata passed through drill holes in the zygomatic arch and the condyle [16] (Fig. 7.6).

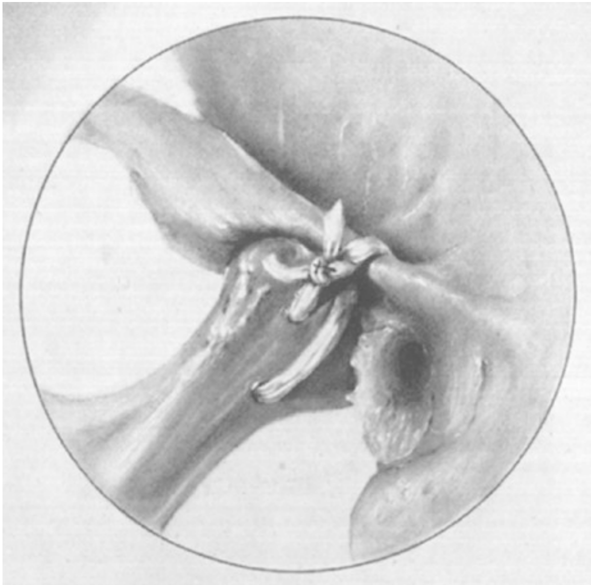

Fig. 7.6 Picture of the tethering technique by Gordon [16]

Another tethering (but anecdotal) technique is the use of Dacron® (Mersilene) strip to ligate the zygomatic arch to the condyle [45]. The ligature acts like an artificial ligament. This technique was described in 1965 by Georgiade and involves drilling small holes into the extracapsular portion of the condylar neck and through the zygomatic arch just anterior to the articular tubercle. Long-term efficacy of this procedure has not been reported.

Take-Home Messages for Soft Tissue Procedures

- Reports remain rare.
- No long-term follow-up available.
- Rarely used.

Summary Take-Home Messages

- Importance of the diagnosis and etiology of the dislocation.
- Open surgical procedures like the Dautrey or eminectomy have good success rates but complications related to the preauricular incision.
- Minimally invasive techniques (discussed in other chapters) like autologous blood injection and arthroscopic scarification or eminectomy are promising.
- Botox injection into the lateral pterygoid muscles is useful for patients suffering from neuromuscular disorders.

Conclusion

Determining the etiology of mandibular dislocation is critical to achieving successful treatment outcomes.

Dislocation can be of several origins:

- Extreme mouth opening (yawning, vomiting, etc.)
- Traumatic (e.g., seizures)
- Iatrogenic (dental procedures, intubation, etc.)
- Ligament and capsular laxity (from connective tissue disorders, e.g., Marfan's syndrome, Ehler-Danlos syndrome)
- Psychogenic
- Neuromuscular
- Drug induced: medications with extrapyramidal effects due to dopamine blockade (phenothiazine, metoclopramide, antipsychotic)
- Idiopathic

Altered structural bone components, e.g., elongated articular eminence

- Patients suffering from recurrent dislocation secondary to neuromuscular diseases can be treated successfully with Botox injections. This is discussed further in Chap. 5.

- Injection of sclerosing agents has shown the potential for many complications, and the unpredictable results associated with this technique make it unsuitable as a first line of treatment for recurrent dislocation. This is discussed further in Chap. 5.

- Grafting procedures necessitate bone harvesting with morbidity associated with the donor site. Moreover, graft resorption is unpredictable.

- Metallic obstacles like plates have shown some success but are prone to fracture and can place the condyle at risk of resorption.

- The most popular technique for clearing the path is eminectomy, which shows a good success rate. Nevertheless, it is still an open joint procedure which puts the patient at risk of facial paralysis and scarring. This is discussed further in Chap. 6.

- Arthroscopic scarification of retrodiscal tissues is a minimally invasive technique with promising results. This is discussed further in Chap. 8.

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Arthroscopic Management of TMJ Dislocation

8

Salvatore Sembronio, Antonio Russillo, Aldo Bruno Giannì, and Massimo Robiony

8.1 Introduction

Dislocation of the temporomandibular joint and repositioning of the dislocated mandible are important topics in oral and maxillofacial surgery. The first surgical techniques for preventing and treating recurrent mandibular dislocation were described in the late 1800s and the early 1900s [1, 2].

Terminology used in the literature to describe this condition can be confusing and contradictory; temporomandibular joint dislocation has also been described as mandibular dislocation, condylar dislocation, and luxation [3].

Dislocations can be subdivided into self-reducing and non-self-reducing. This depends on whether the patient is capable of reducing the dislocation. The self-reducing dislocation occurs when the condyle translates anterior to the articular eminence, whereas the disc is in a posterior position relative to the condylar head; the patient exhibits a temporary open lock that can be reduced spontaneously or with self-manipulation. The non-self-reducing dislocation occurs when the condyle locks anterior to the eminence and becomes fixed in that position due to muscular spasm; this condition requires a medical maneuver to relocate the condyle in its normal anatomic position [4, 5].

It is important to note that joint hypermobility or joint laxity is often found in these cases (Fig. 8.1).

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S. Sembronio (✉) • M. Robiony
Department of Medicine, Maxillofacial Surgery Academic Hospital, University of Udine, Udine, Italy
e-mail: info@sembroniomaxillo.com

A. Russillo • A.B. Giannì
Department of Maxillofacial Surgery, University of Milan, Milan, Italy

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Fig. 8.1 CT scan shows condylar translation above the tubercle with hypermobility of the joint

Recurrent dislocation of the TMJ may cause injury to the disc, the capsule, and ligaments, leading to progressive TMJ internal derangement.

Indications for surgery and surgical options will be discussed in the first part of this chapter, and the author's experience together with the arthroscopic surgical technique will be presented in the second part of this chapter.

8.2 Indications for Surgery and Surgical Options

The treatment is different if managing a single acute episode compared to a recurrence of TMJ dislocation.

In an acute episode, the treatment for non-self-reducing dislocation is conservative in nature with manual closed reduction followed by immobilization of the mandible with a bandage or intermaxillary fixation. Other conservative methods include physiotherapy, muscle relaxants, application of local anesthetic, injection of botulinum toxin to various muscles of mastication, injection of sclerosing agents, and prosthetic restoration of the vertical height.

In the authors' opinion, surgical therapy is indicated when conservative treatment methods have failed and when the patient has had at least three non-self-reducing episodes in the last year.

Surgical options for the treatment of this pathologic condition are divided into three main categories:

1. Restriction of joint movement
2. Augmentation of the articular eminence
3. Removal of barriers to allow for a smooth path of translation [6]

Recurrent TMJ dislocation has been treated by open surgery for many years. Surgical techniques used to limit excessive translation of the condyle are capsular plication [7], lateral pterygoid myotomy [8], and scarification of the temporalis muscle [9].

Augmentation of the eminence is obtained by down-fracturing the zygomatic arch via the LeClerc technique [10] or bone grafting the eminence [11]. Other techniques include alloplastic augmentation of the eminence with titanium miniplates [12], Silastic implants [13], Vitallium mesh or steel screws [14], metal prostheses [15], or blocks of hydroxyapatite [16].

Myrhaug open eminectomy [17] and condylectomy [18] act by removing the barrier to spontaneous reduction of the joint.

Many authors have also described minimally invasive approaches to treating TMJ dislocation.

Machon et al. [6] describes his experience with autologous blood injection that results in the formation of fibrous tissue and ultimately with joint stiffness.

Surgical arthroscopy for the treatment of hypermobility and recurrent dislocation was reported by Ohnishi in 1989 [19]. He described a posterior scarification procedure using a holmium:YAG laser at the level of the oblique protuberance of the upper joint space anteriorly and posteriorly, with arthroscopic suturing of the disc, where the suture was used to limit condylar movements during the healing phase. A 93% success rate was quoted.

In 1992, Merril described arthroscopic sclerosis of the oblique protuberance by injecting sclerosing agents under direct vision in order to obtain scarification of the retrodiscal tissues [20]. In 1996, McCain described an arthroscopic procedure to treat mandibular dislocation via a small incision in the oblique protuberance and electrocautery inserted in the wound, thereby creating scar tissue that inhibits the forward motion of the condyle and disc [21]. Furthermore, in 1998, Chossegros reported arthroscopic coagulation of the retrodiscal tissue using a bipolar diathermy probe [22].

Arthroscopic eminoplasty introduced by Quinn [23] and Moses [24], as an optional procedure for internal derangement of the TMJ, was used for the first time by Segami [25] in 1999 for treating recurrent TMJ dislocation. During the procedure, the articular eminence was reduced using an electric shaver, and the anterior slope of the eminence was made as smooth as possible. Segami advocated always performing a bilateral procedure even if the dislocation was unilateral. Sato et al. in 2003 compared arthroscopic procedures with conventional open eminectomy, and for the arthroscopic eminoplasty, he determined a 77% success rate with 6 recurrences recorded of the 24 joints treated in total [26].

Torres and McCain in 2012 [3] introduced a variation of the original technique by Ohnishi with electrothermal capsulorrhaphy of the oblique protuberance and capsular wall. In this procedure, a shrinkage synovia is obtained, and this limits forward translation of the mandibular condyle and ultimately prevents dislocation or painful subluxation. An 82% success rate was obtained for this technique.

However, an overall success rate of 95% was achieved by the technique of arthroscopic cauterization of the retrodiscal tissue reported by Ybema et al. [27].

A literature review reveals that arthroscopic surgery is a successful procedure for treating mandibular dislocation. Due to the minimally invasive nature of the procedure, it can be used as the first-choice treatment modality for patients requiring surgery.

Table 8.1 Patient characteristics

Age (years)	Sex	Site	Recurrence	Follow-up
22	F	U	No	6 years
35	F	B	No	12 months
30	F	B	No	12 months
29	F	B	No	4 years
25	M	U	No	3 years
45	F	B	No	2 years
32	M	B	Yes	5 years
35	F	U	No	2 years
45	F	U	No	3 years
29	F	B	No	12 months
21	M	U	No	4 years
26	F	B	No	5 years
29	M	B	No	4 years
20	F	U	No	6 years
27	M	U	No	4 years
41	F	B	No	3 years
19	F	B	No	5 years
38	F	U	No	2 years
41	F	U	No	6 years

U - Unilateral, *B* - Bilateral

8.3 Authors' Experience

The arthroscopic procedure that we use in the surgical treatment of recurrent TMJ dislocation is a combination of two techniques: capsulorrhaphy and retrodiscal tissue cauterization in conjunction with eminoplasty.

Nineteen patients treated between 2010 and 2016, who underwent arthroscopic surgery (capsulorrhaphy and retrodiscal tissue cauterization in combination with eminoplasty) for recurrent TMJ dislocation, were analyzed retrospectively. All patients previously underwent unsuccessful conservative treatment and had more than three non-self-reducing episodes in a year. The surgery was performed by the same arthroscopic surgeon in all cases (Table 8.1).

Ten patients suffered bilateral symptoms and nine unilateral; the average mouth opening without locking was 3 cm and the follow-up period ranged from 1 to 6 years.

Success was determined by the absence of recurrent dislocation.

8.4 Preoperative Assessment

As suggested by Undt [28], it is important for the surgeon to know the anatomical conformation of the articular eminence when performing surgical reduction of this structure, in order to avoid penetrating the infratemporal fossa or the middle cranial fossa. All patients were evaluated from a clinical perspective, and a CT and MRI scan were performed. This enabled assessment of the paracoronal sections and estimation of the bone thickness that from anatomical studies were determined to be between 0.1 and 8 mm in the deepest portion of the fossa [29] (Fig. 8.2).

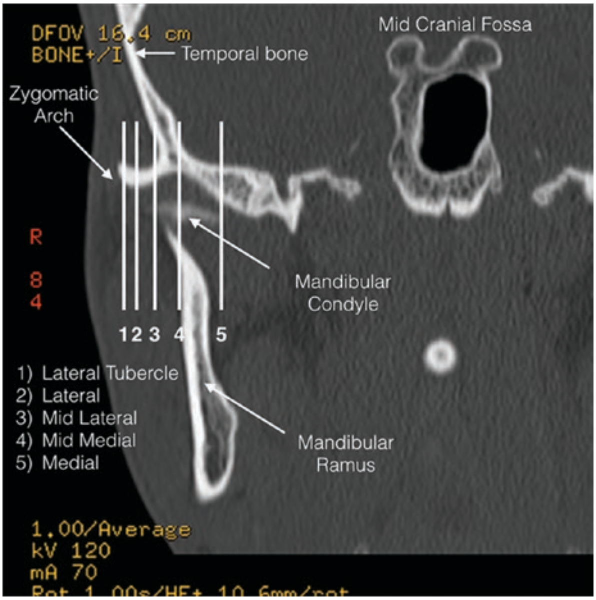

Fig. 8.2 Coronal CT scan of the articular eminence. The amount of bone is usually measured using multiple coronal slices [29]

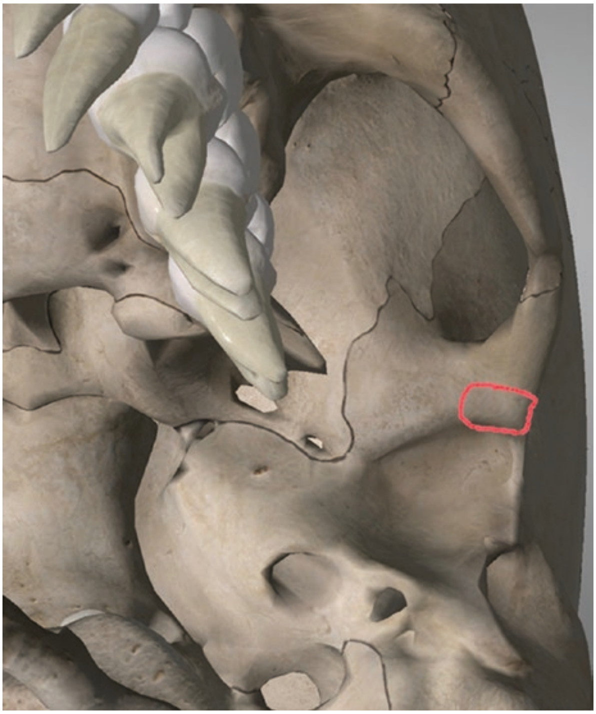

Fig. 8.3 Anatomic view of the skull base that outlines the margins for an eminoplasty, as recommended by the authors

Consequently, the authors recommend remodeling only the lateral portion of the tubercle, thereby performing an eminoplasty and not an eminectomy (Fig. 8.3).

8.5 Arthroscopic Surgical Procedure

The procedure was conducted under general anesthesia after mandibular dislocation was confirmed.

The surgical procedure began with a conventional diagnostic and operative arthroscopy. The puncture technique (double puncture) as described by McCain [30] was used to arthroscopically access the joint. After insertion of the first portal into the posterior recess of the upper joint compartment by an inferolateral approach, the diagnostic sweep was completed, findings were confirmed, and specific attention was paid to the posterior pouch (posterior recess) to visualize both the oblique protuberance (Fig. 8.4) and the articular eminence (intermediate and anterior recess) (Fig. 8.5).

A second "operative" portal was then inserted into the most anterolateral aspect of the joint using the triangulation technique (Fig. 8.6).

An eminoplasty was performed after the double puncture by introducing an electric motorized shaver into the operative cannula. With an aggressive blade (Stryker®), all the cartilage was removed, the bone was visualized, and an eminoplasty of the lateral part of the tubercle was performed (Fig. 8.7).

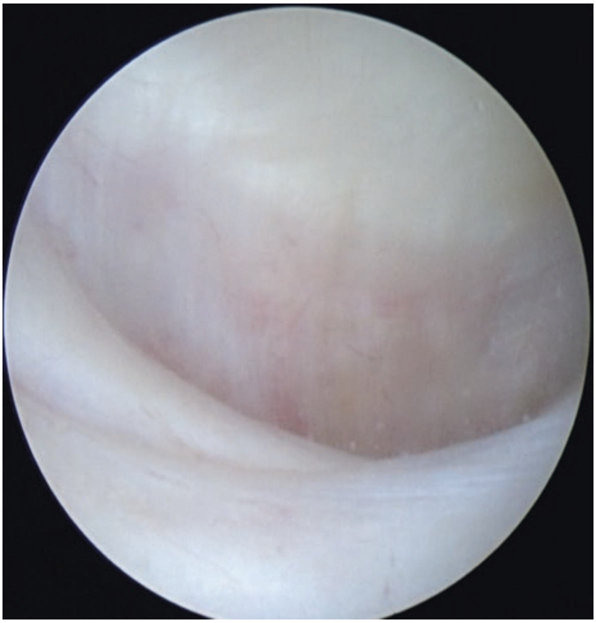

Fig. 8.4 Arthroscopic view of the posterior recess area

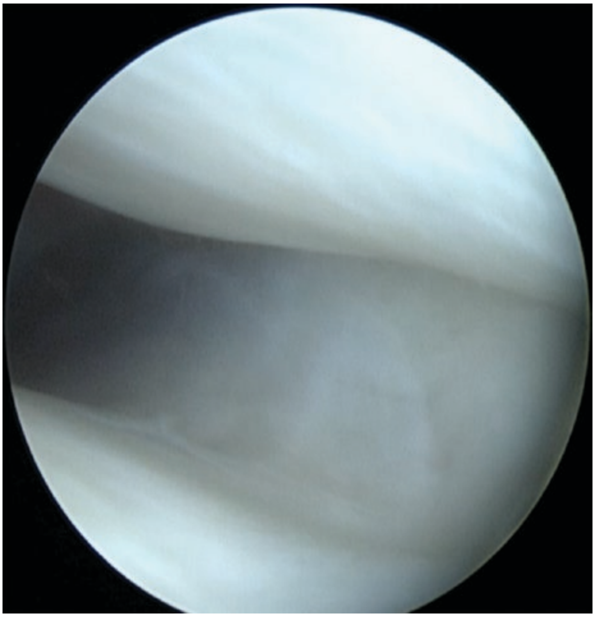

Fig. 8.5 Arthroscopic view of the articular eminence area

Fig. 8.6 Triangulation technique demonstrating the two portals of entry

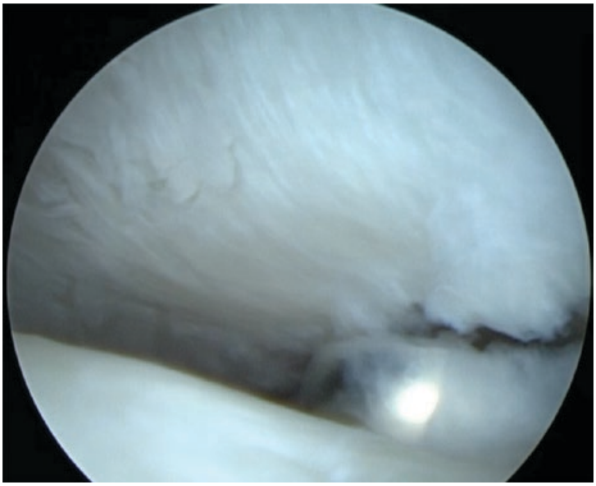

Fig. 8.7 Arthroscopic view of the articular eminence showing the aggressive blade used to reshape the lateral portion

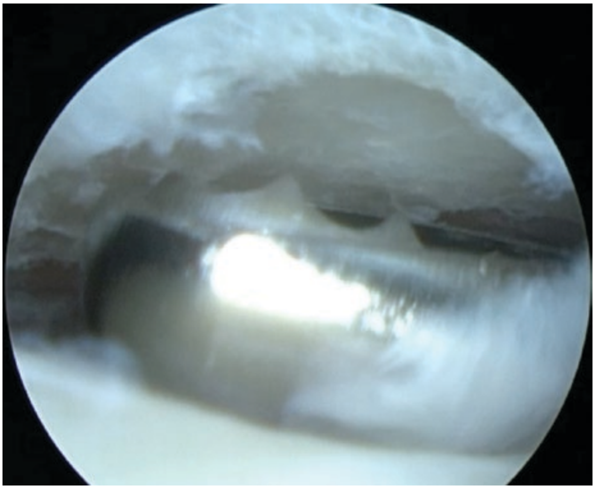

Fig. 8.8 Arthroscopic view of the completed eminoplasty

Between 2 to 4 mm of the lateral portion of the tubercle was removed (Fig. 8.8). This amount of bony reduction was sufficient to obtain the expected results.

A diamond burr is used if the tubercle is particularly high (Fig. 8.9).

The joint space was irrigated to remove the remaining bone and cartilage debris.

As soon as the eminoplasty was completed, a radiofrequency probe (Coblator, Arthrocare®) was introduced into the superior joint space through the operative cannula.

Coblation itself is a low-temperature technique (40–70°) that breaks and debrides targeted tissues with minimal effects on the surrounding tissues. Other conventional devices (lasers, electrosurgical units) use less precise thermal energy to cut or coagulate tissues with temperatures that can reach 400 °C. The coagulating properties of coblation result in an effective posterior scarification without any cautery damage.

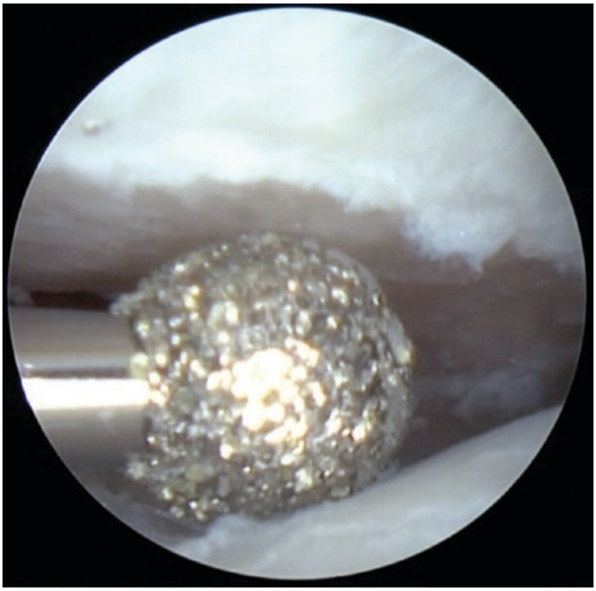

Fig. 8.9 A diamond burr can be used in some cases for reshaping the articular eminence

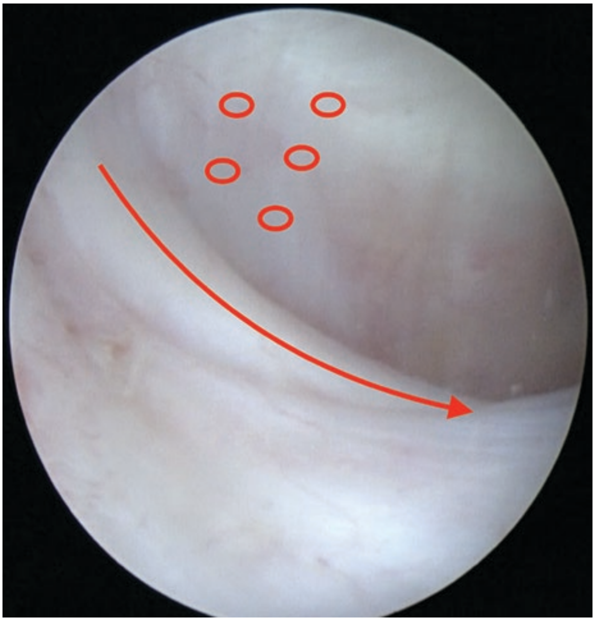

Fig. 8.10 Arthroscopic view of the posterior recess, the oblique protuberance, and sites of lesional burns

Retrodiscal tissue cauterization using radiofrequency was performed along the oblique protuberance (Fig. 8.10) and the posterior capsular wall, which produced a surgical wound and contracture of the tissues in this area during the healing process; shrinkage of the synovium was obtained. Synovectomy of the retrodiscal tissues was also performed when the synovium was fluffy and redundant (Fig. 8.11).

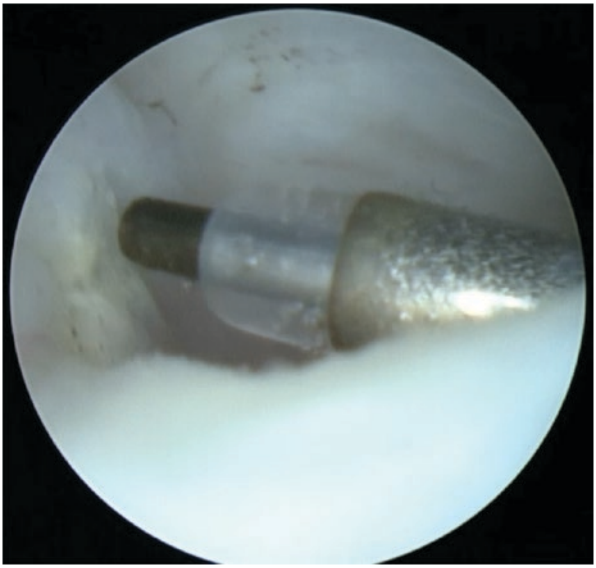

Fig. 8.11 Arthroscopic view of the radiofrequency probe and the coblation scarification of the retrodiscal tissues

8.6 Postoperative Management and Results

At the end of the procedure, intermaxillary fixation was applied for 4 weeks using bilateral class I elastics (Fig. 8.12) to encourage the formation of adhesions.

The patients then started exercises to increase the range of motion to a maximum excursion of 40 mm.

The patients were reviewed weekly by the same clinician, and the mandibular function was carefully controlled.

A magnetic resonance imaging (MRI) and CT scan were performed 6 months after the procedure.

There were no signs of recurrence or any significant postoperative loss of function in 18 of the 19 patients. One patient had postoperative recurrence associated with muscle dystonia that required Botox injection. The success rate of our arthroscopic procedure was 95%.

8.7 Rationale and Conclusions

In accordance with previous studies, the authors believe that effective treatment of this TMJ pathology is mainly due to scarification in the upper joint space rather than a reshaping of the upper joint compartment by reduction of the articular eminence.

As reported by Undt [28], the eminoplasty can be considered to be a block procedure for the TMJ (Fig. 8.13). The bony injury promotes the formation of scars and adhesions between the tubercle, the disc, and the condyle that in

Fig. 8.12 Placement of brackets and postoperative elastic intermaxillary fixation

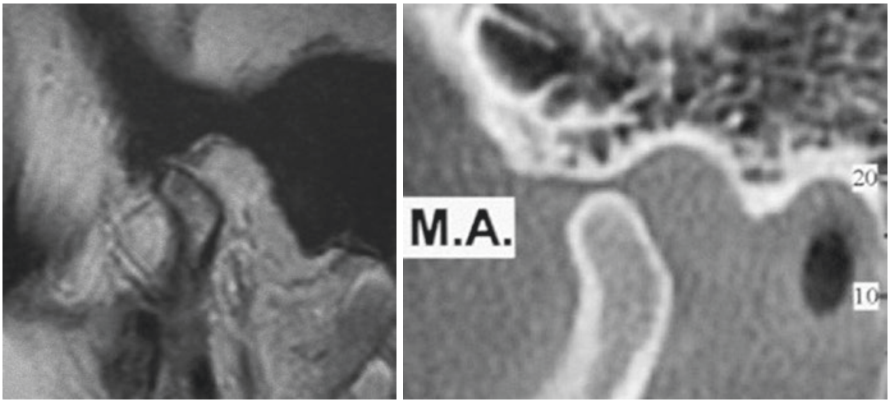

Fig. 8.13 Parasagittal MRI scan and CT scan in the open mouth position 6 months after the arthroscopic procedure. Note the remodeled tubercle after the eminoplasty and the translation of the disc-condyle complex

addition to bone remodeling causes a limitation of condylar movements. Commensurate with Undt's work, we prefer the eminoplasty procedure over the eminectomy. The remodeling of only the lateral part of the tubercle promotes the formation of scars and adhesions, ensuring a more effective procedure. The procedure should be performed bilaterally, only if necessary and in the presence of signs of dislocation.

Electrothermal capsulorrhaphy is a well-established treatment modality in the orthopedic literature for the treatment of hypermobile joints. In the temporomandibular joint, capsulorrhaphy and the retrodiscal cauterization of the oblique protuberance and the posterior capsular wall, are responsible for the arthroscopically observed synovial shrinkage that results in an approximate 15% change, thereby enhancing the effect of the eminoplasty.

The oblique protuberance is a structure with numerous collagen fibers (type 1 and type 3). The scar created by the cauterization inhibits condylar and disc mobility by second-stage healing [3].

The placement of intermaxillary elastic fixation complements the goal of the procedure.

As suggested by McCain [3], the use of elastics can be considered a reverse physical therapy. The immobilization of the capsule and ligaments during healing is essential and can prevent ligaments reverting to pretreatment lengths.

We therefore conclude that the two arthroscopic procedures, capsulorrhaphy and retrodiscal tissue coblation, in conjunction with eminoplasty, are highly successful minimally invasive procedures for recurrent and painful temporomandibular joint dislocation. These procedures are highly recommended by the authors.

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Role of Total Joint Replacement in the Management of Chronic TMJ Dislocation

9

Nigel Shaun Matthews and Russell Eric Warburton

9.1 Introduction

Temporomandibular joint (TMJ) dislocation is characterized by irreducible displacement of the mandibular condyle from the glenoid fossa. Condylar displacement is most frequently bilateral [1] and is typically accompanied by significant pain, malocclusion, and masticatory dysfunction.

TMJ dislocation can be described as acute, recurrent, or chronic [2]. Acute or recurrent dislocation is frequently encountered and can often be reduced by manual manipulation of the mandible with relative ease. Chronic or long-standing dislocation is rare but requires challenging, invasive surgical intervention to correct the malocclusion and restore both facial form and masticatory function.

In this chapter, a case of chronic TMJ dislocation is described which demonstrates the difficulty in managing chronic dislocation and underscores the importance of early recognition and treatment. The etiology, pathophysiology, and management strategies detailed in the literature are discussed. The potential role of alloplastic reconstruction of the TMJ in the management of chronic dislocation is also presented.

N.S. Matthews, F.D.S., F.R.C.S., F.R.C.S (OMFS) (✉)
Department of Oral and Maxillofacial Surgery, School of Dentistry, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA
e-mail: shaun_matthews@unc.edu

R.E. Warburton, D.M.D., M.D.
Department of Oral and Maxillofacial Surgery, School of Dentistry, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

Knoxville, TN, USA

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9.2 Etiology

Chronic TMJ dislocation is an inevitable sequelae of an acute dislocation that goes unrecognized or undertreated. This can occur spontaneously or as a result of trauma, seizure, medication-induced dystonia [3], or excessive mouth opening during endoscopy, laryngoscopy, or dental procedures [4]. TMJ dislocation occurs more frequently in patients with systemic disease such as Ehlers–Danlos [5], myotonic dystrophy [6], multiple sclerosis, and Parkinson's disease [7].

There is no agreement in the literature regarding the definition of chronic TMJ dislocation. It was initially defined by Fordyce et al. [8] as a dislocation that persists for more than 1 month, but more recently, Huang et al. [9] proposed that any dislocation left untreated for greater than 72 h should be considered chronic. This suggested change takes into consideration the resolving acute inflammatory response after injury and the onset of granulation tissue formation.

Failure to identify TMJ dislocation in the acute stage is attributable to several factors, including failure to seek prompt medical evaluation, frequently caused by lack of finances or available medical resources [10]. Many medical practitioners are unacquainted with the clinical signs and symptoms of TMJ dislocation which can result in misdiagnosis and delayed patient care.

Elderly and medically compromised patients are particularly susceptible to TMJ dislocation going undetected [11, 12]. Huang et al. reported six cases of chronic dislocation, four of which were in elderly patients following a protracted ICU admission [9].

9.3 Pathophysiology

Progressive periarticular fibrosis, intra-articular adhesions, and dense fibrous ingrowth into the glenoid fossa [1, 13] are characteristics of chronic TMJ dislocation (Fig. 1). Posterior movement of the condyle can be further inhibited when the articular disk becomes displaced behind the anteriorly positioned condyle, and prolonged dislocation [13–15] can result in significant spasm and shortening and fibrosis of the masticatory muscles. Degenerative condylar changes have also been reported [16, 17]. The most important factor preventing the restoration of the condyle to an acceptable anatomical position in the glenoid fossa is the progressive fibrosis of the TMJ; it is this that differentiates chronic dislocation from other types.

9.4 Diagnosis

It is important to take a detailed patient history in order to establish the duration and likely cause of the dislocating episode. Particular attention should be paid to any past history of TMJ dislocation or pathology.

Fig. 9.1 Ingress of fibrous tissue (*white arrow*) into the glenoid fossa of a chronically dislocated mandibular condyle

A comprehensive TMJ examination should be completed on any patient with a suspected dislocation. An elongated face and prognathic profile [13, 18] are characteristics of bilateral TMJ dislocation; the mandibular condyles are impalpable within the glenoid fossae [2]. Often the patient will exhibit pronounced apertognathia and collapse of the posterior vertical occlusal height. Unilateral dislocation gives rise to both deviation of the mandible away from the dislocated joint and a contralateral occlusal crossbite [13]. Mandibular movements are limited, and reduced masticatory function, jaw pain, and muscle spasms are frequently described [19].

Suspected TMJ dislocation should be confirmed radiographically [1]. Panoramic radiograph or plain films of the mandible are often sufficient. CT scan is useful to rule out condylar fracture in the setting of a traumatic dislocation or to evaluate for degenerative changes of the condyle (Fig. 9.2).

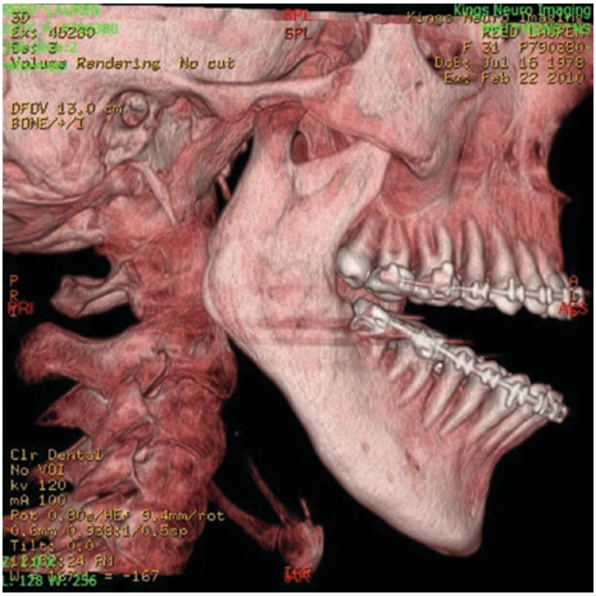


Fig. 9.2 3D CT scan demonstrating TMJ dislocation anterior to the articular eminence

9.5 Management

Management of chronic TMJ dislocation is focused on the re-establishment of a stable, functional occlusion with restoration of masticatory function and correction of any associated dentofacial deformity [20]. Ideally, this is achieved by reduction of the condyle into the glenoid fossa with minimal trauma to the periarticular tissues.

There is no current consensus as to the best method of managing chronic TMJ dislocation. Generally, treatment should begin with nonsurgical interventions and advance to more invasive surgical procedures, as necessary. The longer dislocation persists, the more likely it is that invasive surgical treatment will be required [9, 15, 21, 22]. In a retrospective case series, Ugboko et al. [10] reported on 24 patients treated for chronic TMJ dislocation over a 10-year period. Approximately 21% of cases (5/24) were managed by manual reduction, 25% of cases (6/24) required maxillomandibular fixation with elastic traction, and 54% (13/24) of cases required surgical intervention.

9.6 Alloplastic Temporomandibular Joint Reconstruction

Alloplastic reconstruction of the temporomandibular joint has a well-documented history of successful outcomes in the management of end-stage TMJ disease [23, 24] but has been poorly described in the management of irreducible chronic dislocation. Three cases have been reported in the literature. Tipps et al. [15] reported on

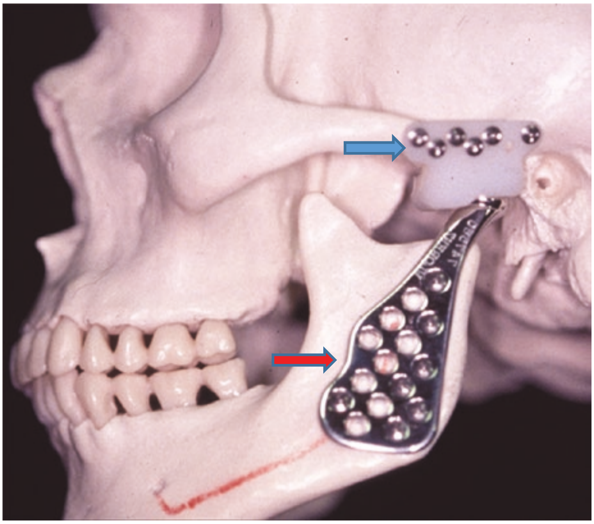


Fig. 9.3 Photograph of Zimmer Biomet stock total joint prosthesis with fossa component (*blue arrow*) and mandibular component (*red arrow*)

Fig. 9.4 Photograph of TMJ Concepts custom total joint prosthesis

the use of silastic blocks to maintain posterior ramus height after bilateral condylectomy in a 13-month-old dislocation. Blank et al. [20] described the use of proplast-coated vitallium condylar prostheses to successfully reconstruct a bilateral 18-month-old dislocation. More recently, Baur et al. [19] reconstructed a 12-week-old bilateral dislocation with stock alloplastic TMJ implants.

The current generation of alloplastic TMJ prostheses has been developed based on orthopedic principles and consists of a two-part system (Figs. 9.3 and 9.4):

- Fossa component—affixed to the zygomatic arch
- Mandibular component—affixed to the ramus of the mandible

The fossa and mandibular components articulate by a hinge movement; no lateral or protrusive movements are possible.

The two most widely used TMJ prostheses are as follows:

- TMJ Concepts—available in custom fit only
- Zimmer Biomet—available in stock and custom fit (not available in the USA)

The fossa component is largely made of ultrahigh molecular weight polyethylene (UHMWPE) material, and the mandibular component is made of a cobalt–chromium–molybdenum alloy.

9.6.1 Surgical Technique

The stepwise surgical technique for alloplastic reconstruction of the TMJ can be summarized as follows:

1. Incision and dissection—preauricular and retromandibular approach (Figs. 9.5 and 9.6).
2. Create gap arthroplasty—condylectomy ± coronoidectomy (Figs. 9.7 and 9.8).
3. Assess range of motion—apply intermaxillary fixation (IMF).
4. Place fossa/mandibular implants (Fig. 9.9).
5. Check occlusion and range of motion (ROM).
6. Secure implants ± place fat graft, if indicated.
7. Close incisions.

9.6.2 Virtual Surgical Planning

Virtual surgical planning (VSP) has evolved into the contemporary method used for planning temporomandibular joint replacement surgery. Its main advantages are

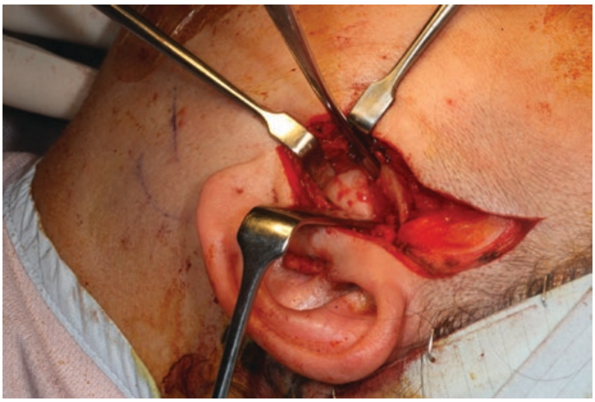


Fig. 9.5 Example of the preauricular incision providing access to the TMJ

Fig. 9.6 Example of the retromandibular incision providing access to the ramus of the mandible

that there is no requirement for on-site wet lab facilities and it avoids the necessity for repeated clinical interventions. Osteotomy cuts and surgical movements are simulated using computer-based CAD–CAM technology via a series of web-based teleconferences between the surgeon and biomedical engineer. This technique is able to anatomically map out the vital structures, design and manufacture bespoke occlusal splints, cutting guides, and implants, and therefore enhance surgical accuracy and patient safety (Fig. 9.10).

9.6.3 Case Report

A 54-year-old female presented with a 3-month history of chronic bilateral TMJ dislocation which was initially unrecognized, following emergency admission to another facility for an unrelated, life-threatening condition. The patient reported ongoing right-sided TMJ pain and difficulty with eating, as a result of her inability to occlude her teeth fully. She denied a past history of clicking, crepitus, or any other associated jaw joint complaints. Despite the patient's efforts to communicate her problem to the medical staff, her concerns went largely unnoticed, and she subsequently presented to an oral and maxillofacial surgeon for definitive treatment 3 months after the inciting episode. The diagnosis of chronic TMJ dislocation was confirmed on radiographs (Fig. 9.11).

Fig. 9.7 Condylectomy and coronoidectomy osteotomy cuts below the level of the sigmoid notch

An initial attempt was made to reduce the condyles by manipulation under general anesthesia, but this proved to be unsuccessful. Delayed resection and reconstruction of the condyles were therefore undertaken and facilitated by virtual surgical planning and the use of stock alloplastic TMJ prostheses (Fig. 9.12).

Custom alloplastic prostheses could have been used via a two-stage technique, but this was deemed to be unwise due to the patient's significant medical comorbidities and her likely inability to tolerate a prolonged period of intermaxillary fixation (during which the custom TMJ prostheses would be fabricated) and a second lengthy surgical procedure.

The patient's surgical procedure and postoperative recovery were uneventful, and she reported an immediate improvement in her masticatory function, resolution of facial pain, and restoration of her occlusion and facial form (Fig. 9.13).

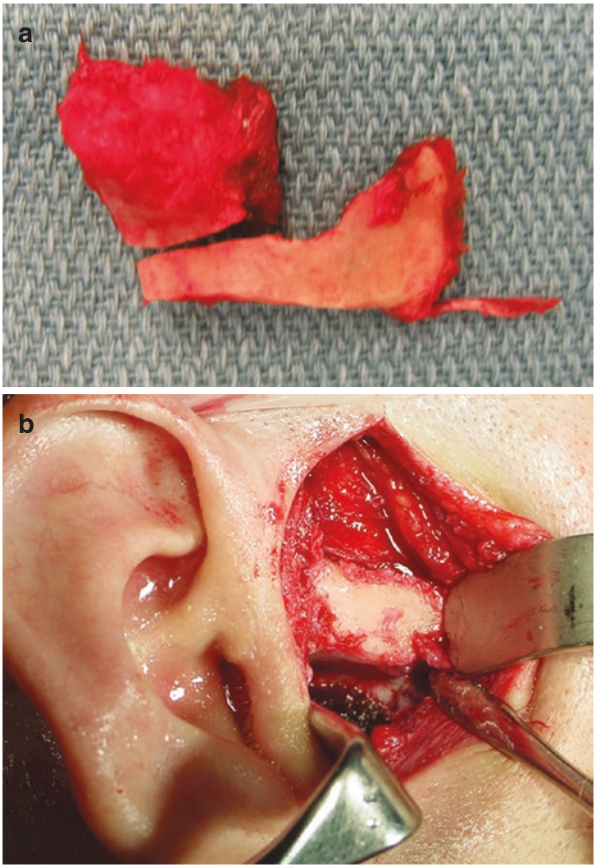


Fig. 9.8 Gap arthroplasty created following resection of the condyle and coronoid process: (**a**) resected specimen and (**b**) in vivo dissection

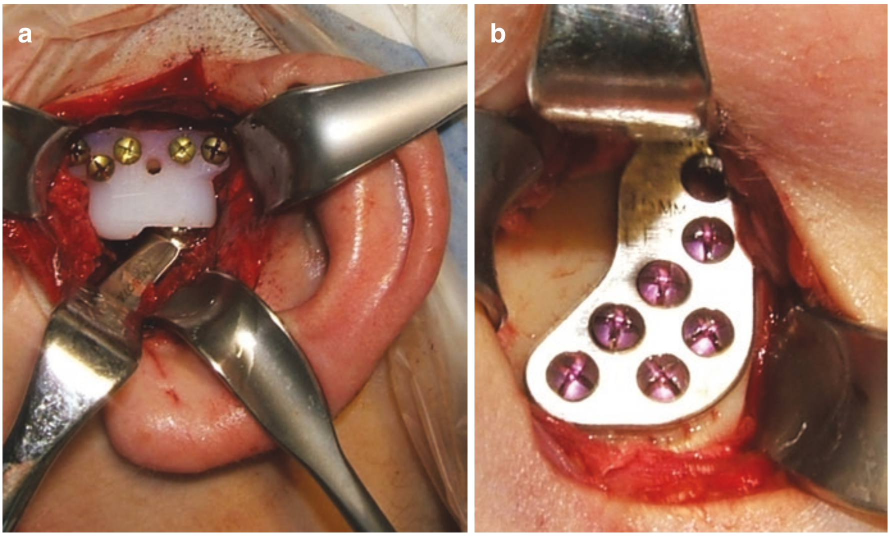


Fig. 9.9 Zimmer Biomet total joint prosthesis demonstrating (**a**) articulation of the fossa and mandibular components and (**b**) footplate of the mandibular component

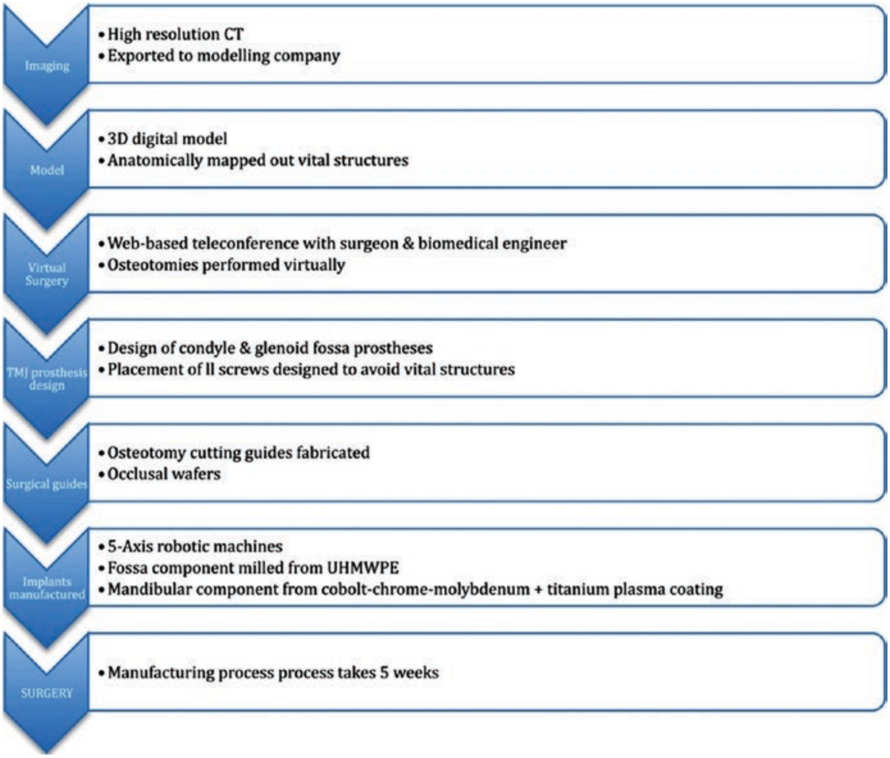


Fig. 9.10 Algorithm of the virtual surgical planning process

Fig. 9.11 Chronic TMJ anterior dislocation: pre-op panorex

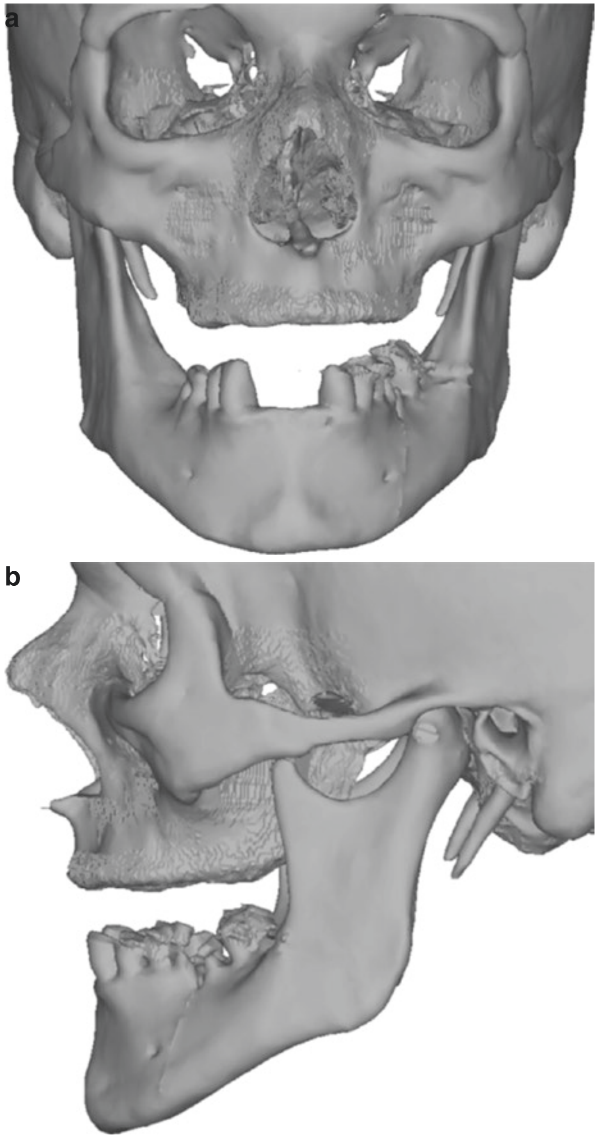
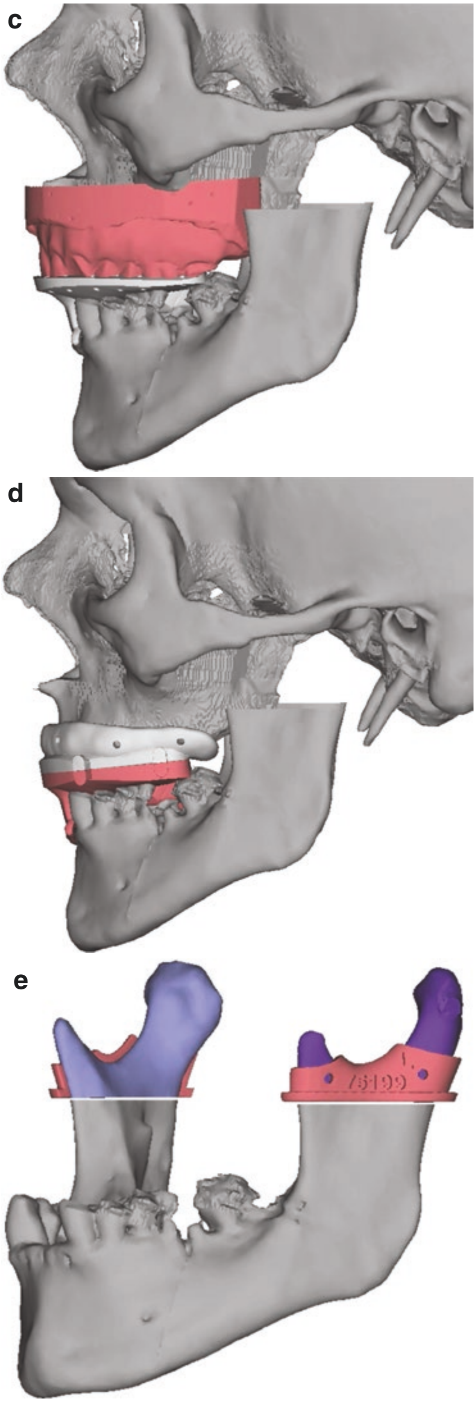


Fig. 9.12 Stages of the virtual surgical planning process for a patient with chronic bilateral TMJ dislocation treated with bilateral total joint replacement prostheses: (**a**) 3D CT scan frontal view, (**b**) 3D CT scan left lateral view, (**c**) cast stone model of the patient's upper denture laser scanned into the 3D CT scan to provide occlusal detail and preservation of the occlusal height, (**d**) in situ upper and lower occlusal splints designed and manufactured using VSP, (**e**) in situ mandibular cutting guide designed and manufactured using VSP, (**f**) upper and lower occlusal splints with locating countersinks (separated), (**g**) upper and lower occlusal splints with locating countersinks (engaged)

Fig. 9.12 (continued)



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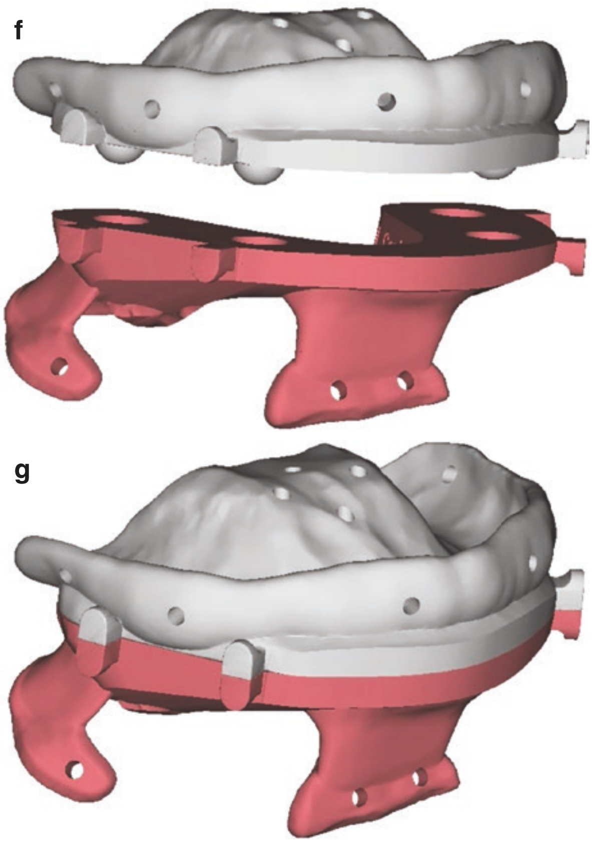

9.6.4 Complications and Post-op Care

There are several potential complications associated with this type of complex surgery, and it is therefore important that patients are fully informed of the possible sequelae related to the procedure. These primarily include the following:

- Facial nerve injury
- Chronic pain
- Loss of jaw joint mobility
- Malocclusion
- Hearing complaints
- Infection
- Dislocation of the implant
- Heterotopic bone formation
- Resorption or corrosion of the surrounding bone
- Foreign body or allergic reaction
- Neuroma formation

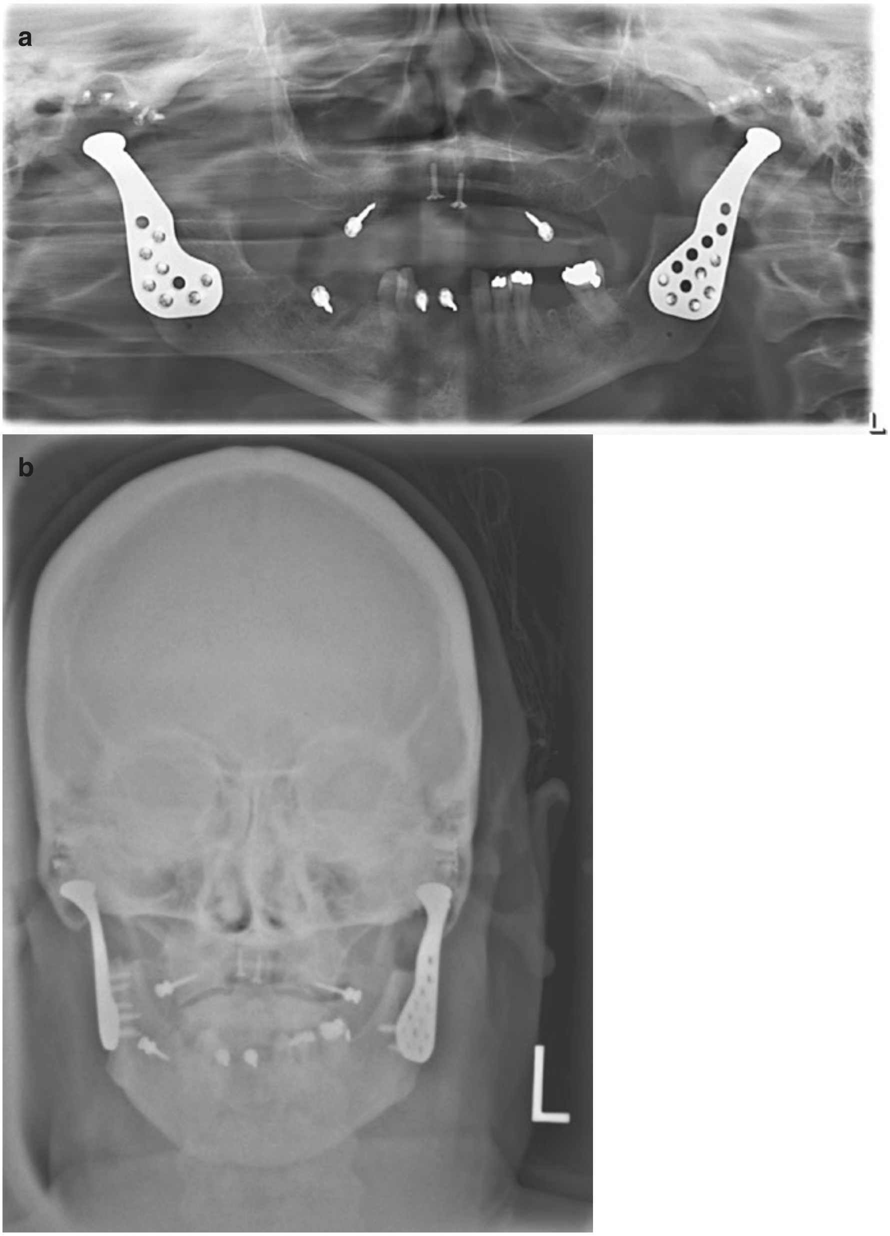

Fig. 9.13 Chronic TMJ dislocation: (a) post-op panorex and (b) post-op PA cephalogram

The meticulous postoperative management of these patients is imperative for a successful outcome and should consist of the following:

- Elastic IMF for 3–5 days to minimize the risk of dislocation
- Antibiotics for 7–10 days

- Analgesics for 2–4 weeks
- Aggressive physical therapy to improve range of motion
- Lifelong prophylactic antibiotics for dental/oral procedures that are likely to cause a bacteremia

9.7 Summary

The described case report is illustrative of the potential benefit of alloplastic reconstruction in the management of irreducible TMJ dislocation, as the patient reported excellent mandibular function with immediate restoration of occlusion and facial form.

Surgeons involved in the management of chronic TMJ dislocation should be prepared for the possibility of open arthrotomy and reconstruction with alloplastic prostheses, and consequently, patients should also be similarly counseled before surgery of the possibility of open arthrotomy, condylectomy, and alloplastic reconstruction, to provide a successful outcome.

In summary, chronic TMJ dislocation often requires surgical intervention to be managed successfully. Significant intra-articular adhesions and periarticular fibrosis can limit mandibular mobility and make closed reduction impossible. Arthrotomy with open manipulation of the mandibular condyle or condylectomy has the potential to lead to significant patient morbidity including postoperative osteoarthritis, ankylosis, or facial deformity. Alloplastic reconstruction may therefore provide a more predicable outcome and should be considered in the management of irreducible chronic TMJ dislocation.

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